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ARC • LNR
Excellence in Agricultural Research and Development

INSTITUTE FOR SOIL, CLIMATE AND WATER

CONTENTS:

agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

South African Weather Service

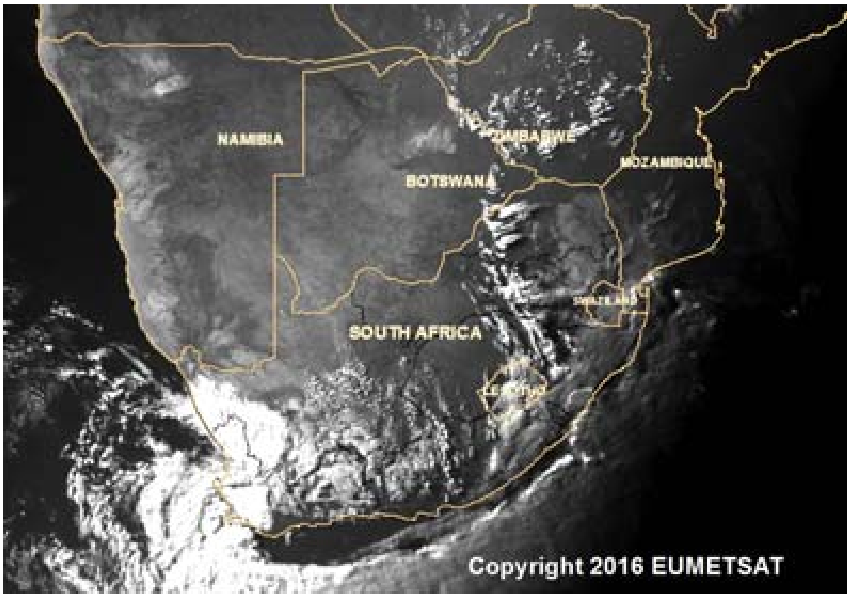
AMESD

146th Edition

Images of the Month

Intense cut-off low causes extreme weather events in late July

The SEVIRI - Visible (Red) Band image from MSG-3 on the afternoon of 26 July 2016 shows at the centre of a spiralling cloud mass the position of an upper-air cut-off low that resulted in the most significant weather events of the month.



Apart from widespread and heavy snow over much of the eastern high-lying areas, severe storms developed over the central to northeastern parts due to the instability associated with the system. These included several hailstorms as well as two tornadoes over Gauteng. The snow in and around Lesotho was the heaviest in many years and necessitated several rescue efforts. Large parts of the Free State received in excess of 50 mm of rain while the southern parts and coastal belt of KwaZulu-Natal received higher falls with as much as 250 mm over a 2-day period in some areas. Most of the precipitation associated with the system occurred from 24-27 July. On the "back side" of the low pressure system, moisture advecting over the southwestern parts and into the western interior (moving clockwise from the south and then eastwards) also resulted in widespread rain over those areas, with some heavy falls along the western Escarpment. The westerly flow that developed over the interior by the 27th resulted in advection of cold dry air over much of the interior, causing widespread frost over most of the country in the wake of the rainfall event.

The development of the system and concurrent inclement weather over the interior was reminiscent of several similar events since late March, resulting in well above-normal rainfall over the central interior and eastern coastal region.

The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured the image (right) of the heavy snow that fell on Lesotho between 24 and 27 July. In an article by Pam Wright (The Weather Channel), Professor Stefan Grab of Wits University mentioned that the snowfall in the area was the heaviest in at least 20 years.

© NASA's Earth Observatory

The Agricultural Research Council - Institute for Soil, Climate and Water (ARC-ISCW) collected the data, generated the products and compiled the information contained in this newsletter, as part of the Coarse Resolution Imagery Database (CRID) project that was funded by the Department of Agriculture and Department of Science and Technology at its inception and is currently funded by the Department of Agriculture, Forestry and Fisheries (DAFF).

Overview:

The most outstanding feature, weather-wise, for July 2016 was again the well above-normal rainfall over parts of the summer rainfall region. This was brought about by an intense cut-off low pressure system that developed over the interior between the 23rd and 27th. A very strong ridge of high pressure to the south of the country, along with the system, resulted in large amounts of moisture being advected into the eastern parts, with cloudy and cold conditions from the 24th to the 26th over many areas with widespread rain over most parts and snow over the high-lying areas.
Rainfall over the winter rainfall region was mostly near normal. Frontal systems were responsible for rain over much of the winter rainfall region around the 5th, 14th, 20th and again by the 26th. Precipitation around the 20th and 26th was the highest, with the second event coinciding with the low pressure system causing precipitation over the interior, followed by another frontal system resulting in continued wet conditions up to the 28th. Rainfall associated with this system over the winter rainfall region was also the most significant for the month, with totals during the other rainfall periods being lower. With more rain towards the second half of the month over the winter rainfall region, maximum temperatures tended to be lower whilst minimum temperatures tended to be higher than during the early part of the month.
Over the interior, including most of the summer rainfall region, temperatures throughout the month remained fairly even. One exception was the cloudy spell associated with the cut-off low and strong high pressure system towards the south from the 24th to the 27th. During this period, maximum temperatures were noticeably lower whilst minimum temperatures remained high due to cloud cover. Cold, dry air spreading across the country in the wake of the precipitation-producing system resulted in the lowest minimum temperatures over the north-eastern parts occurring by the end of the month.
By the very end of the month, yet another (weaker) cut-off low pressure system developed over the southern parts, resulting in thundershowers over the southern interior and some snow on the mountains in and around Lesotho.

1. Rainfall

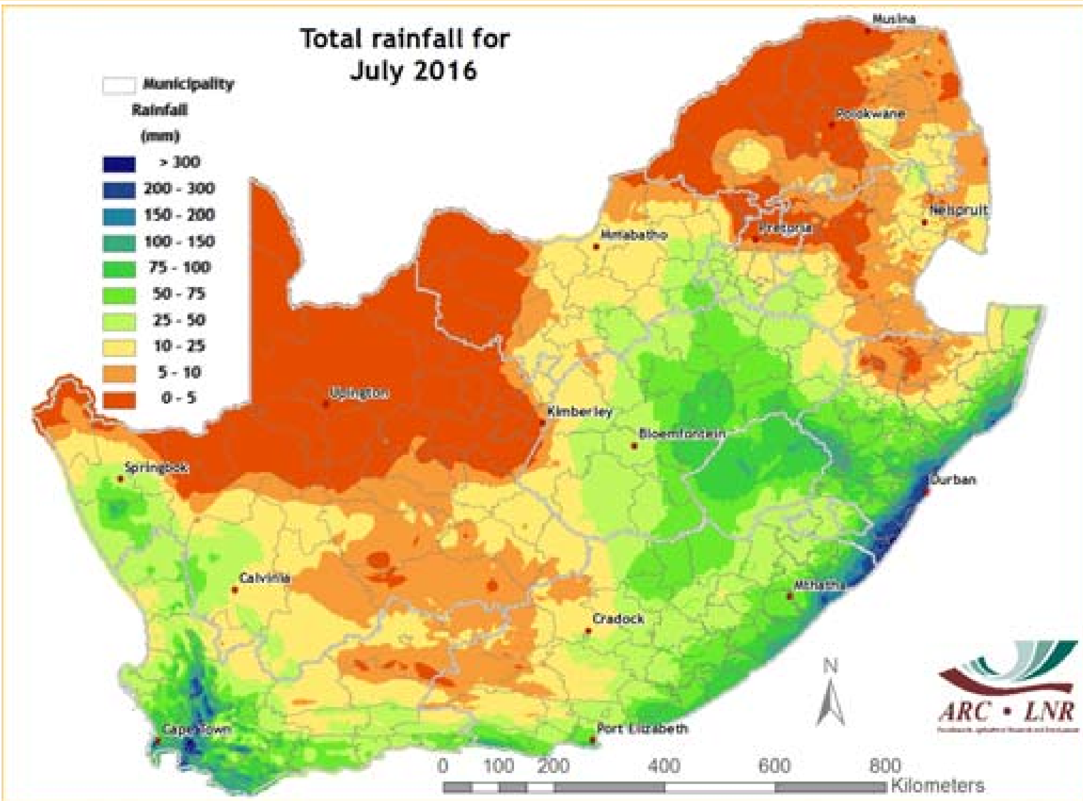
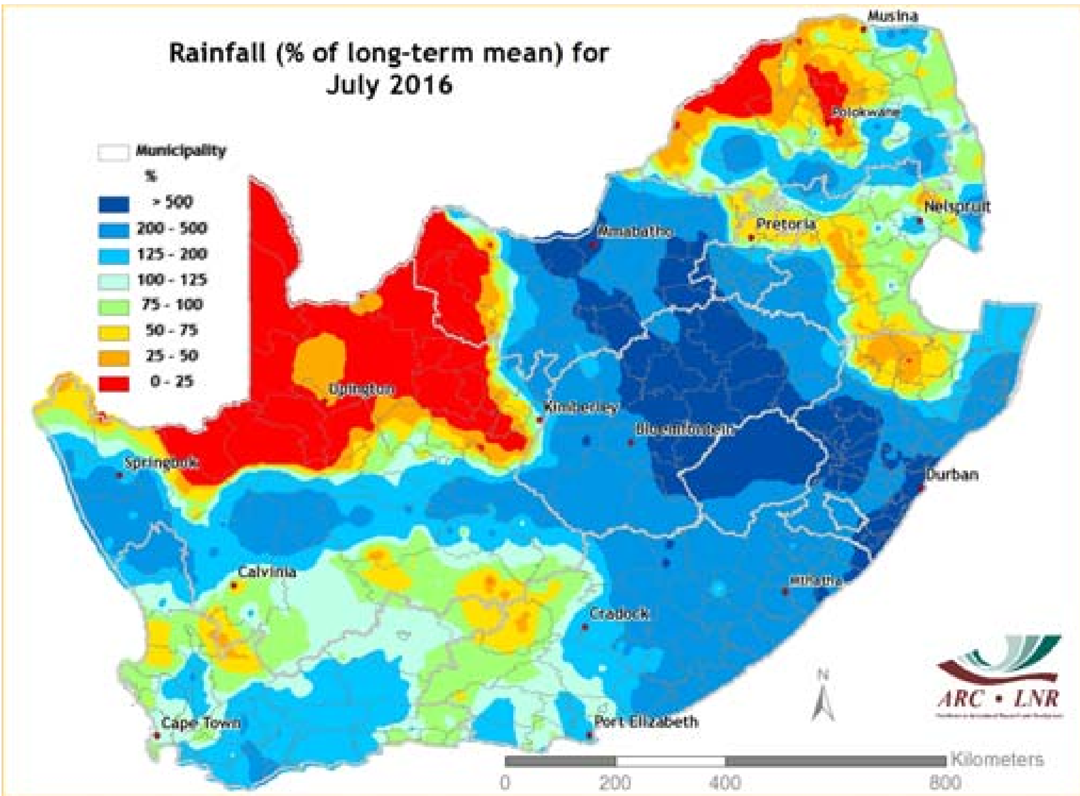


Figure 1



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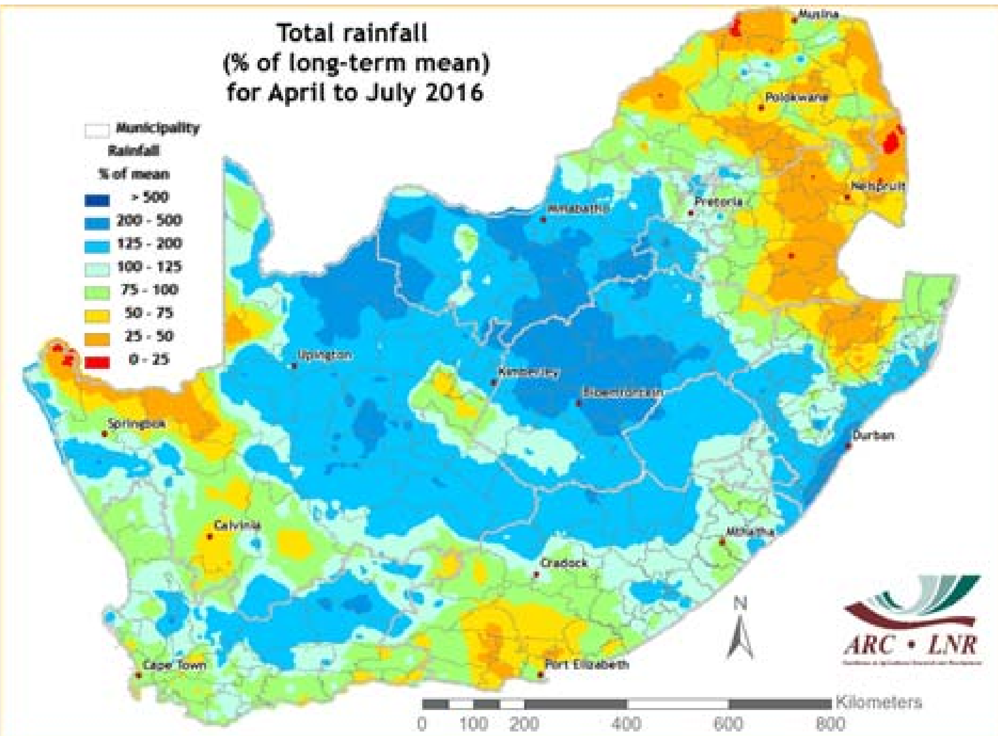

Figure 3

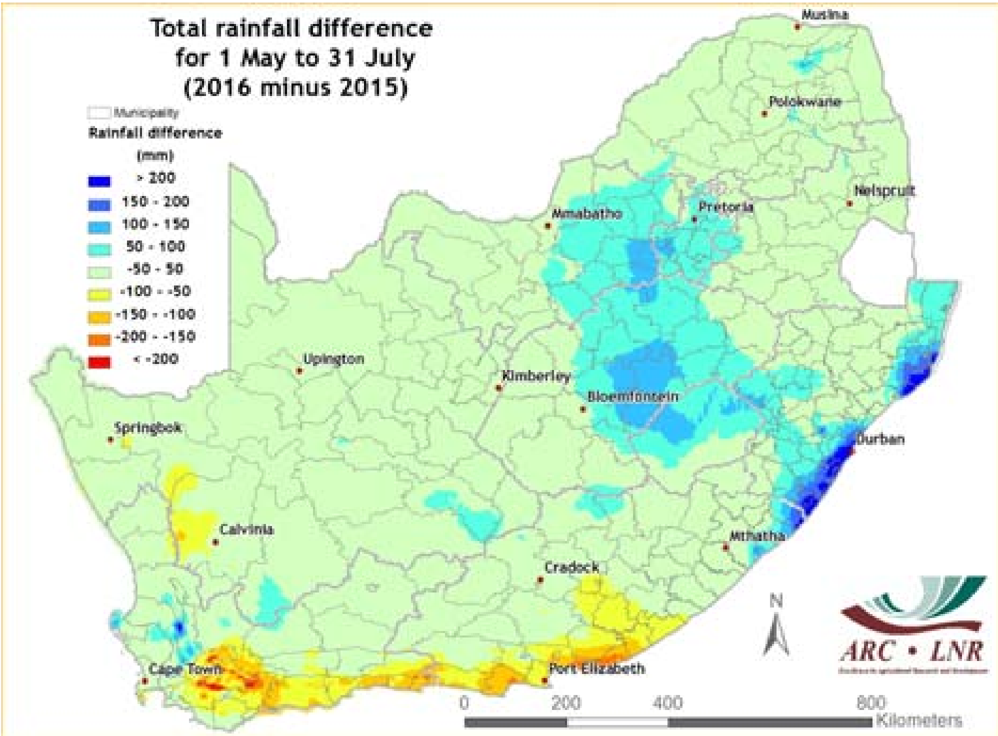

Figure 4

Figure 1:
Rainfall during July 2016 was well distributed throughout both the winter and summer rainfall regions. Large parts of the Free State received in excess of 50 mm of rain. Highest totals for the month were recorded over the coastal belt of KwaZulu-Natal, where isolated areas received more than 300 mm, and over the mountainous Boland in the southwest of the winter rainfall region. The northern parts of the Northern Cape and western Limpopo were mainly dry.

Figure 2:
Much of the winter rainfall region received near-normal rainfall during July. The rainfall over the central parts of the country was well above normal, with large parts of the Free State into southern KwaZulu-Natal receiving more than 500% of the long-term average.

Figure 3:
Much of the central interior has experienced above-normal rainfall since April, with the coast of KwaZulu-Natal and some parts of the winter rainfall region also experiencing above-normal rainfall. Rainfall in the north-east, adjacent to Namibia, and over the western parts of the Eastern Cape was normal to below normal.

Figure 4:
Much of the central interior, the western winter rainfall region and coastal belt of KwaZulu-Natal received significantly more rain during May-July 2016 than in the same period last year. However, the southern parts of the country received much less rain this year.

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2. Standardized Precipitation Index

Standardized Precipitation Index

The Standardized Precipitation Index (SPI - McKee *et al*., 1993) was developed to monitor the occurrence of droughts from rainfall data. The index quantifies precipitation deficits on different time scales and therefore also drought severity. It provides an indication of rainfall conditions per quaternary catchment (in this case) based on the historical distribution of rainfall.

REFERENCE:
McKee TB, Doesken NJ and Kliest J (1993) The relationship of drought frequency and duration to time scales. In: Proceedings of the 8th Conference on Applied Climatology, 17-22 January, Anaheim, CA. American Meteorological Society: Boston, MA; 179-184.

The current SPI maps (Figures 5-8) show that while significantly wet conditions dominate at the shorter time scales over the central interior and towards the coast of KwaZulu-Natal, severe to extreme drought conditions still dominate over the far eastern parts as well as the western winter rainfall region at the longer time scales (12-24 months).

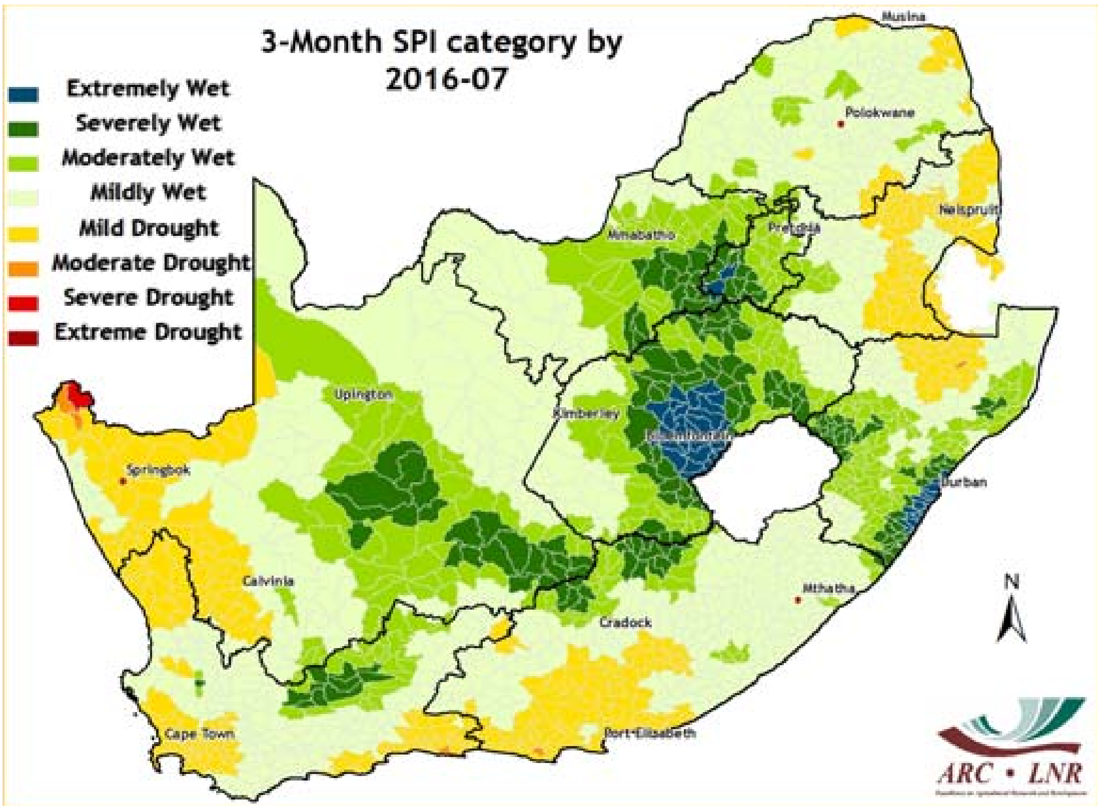
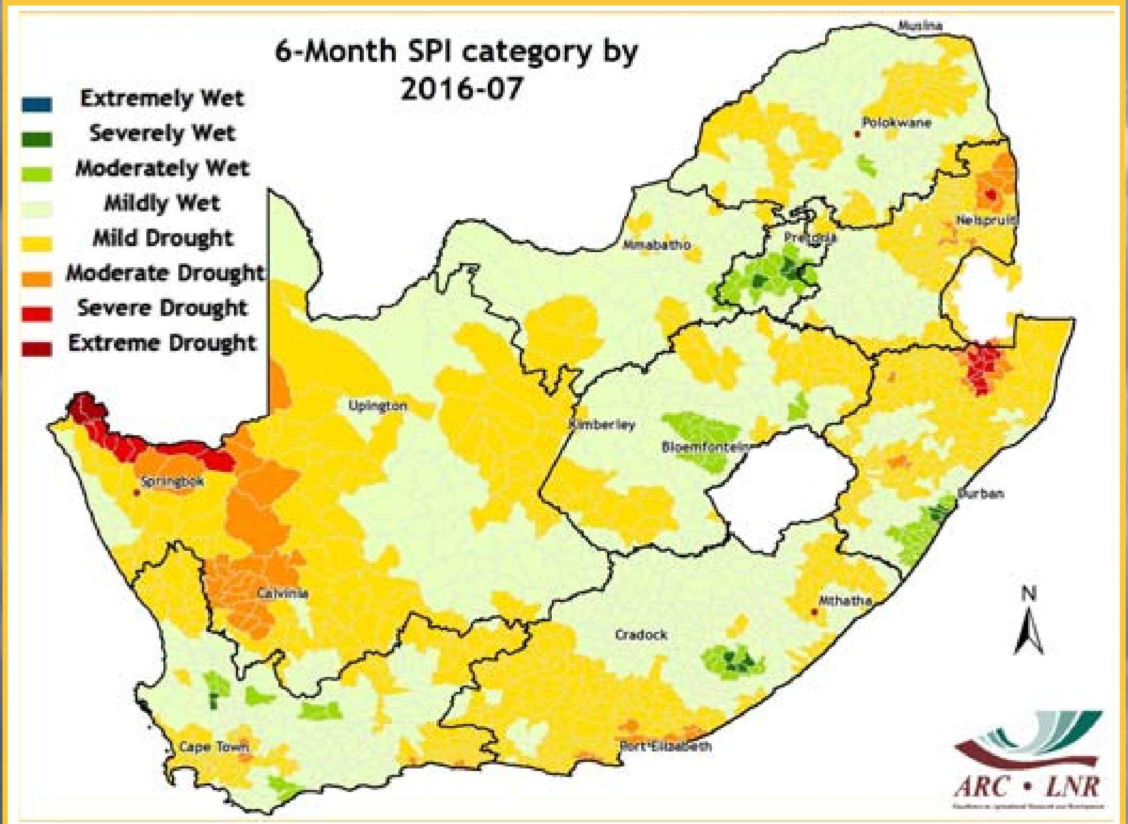


Figure 5



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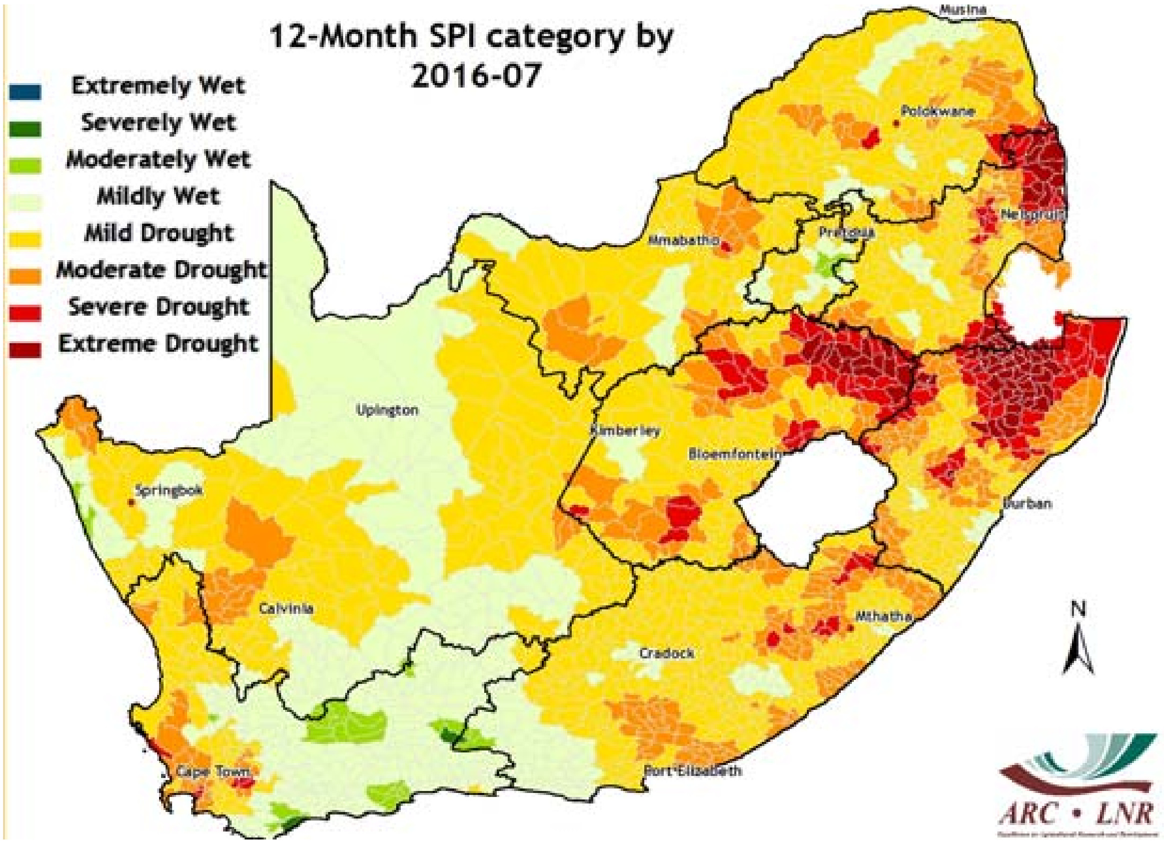

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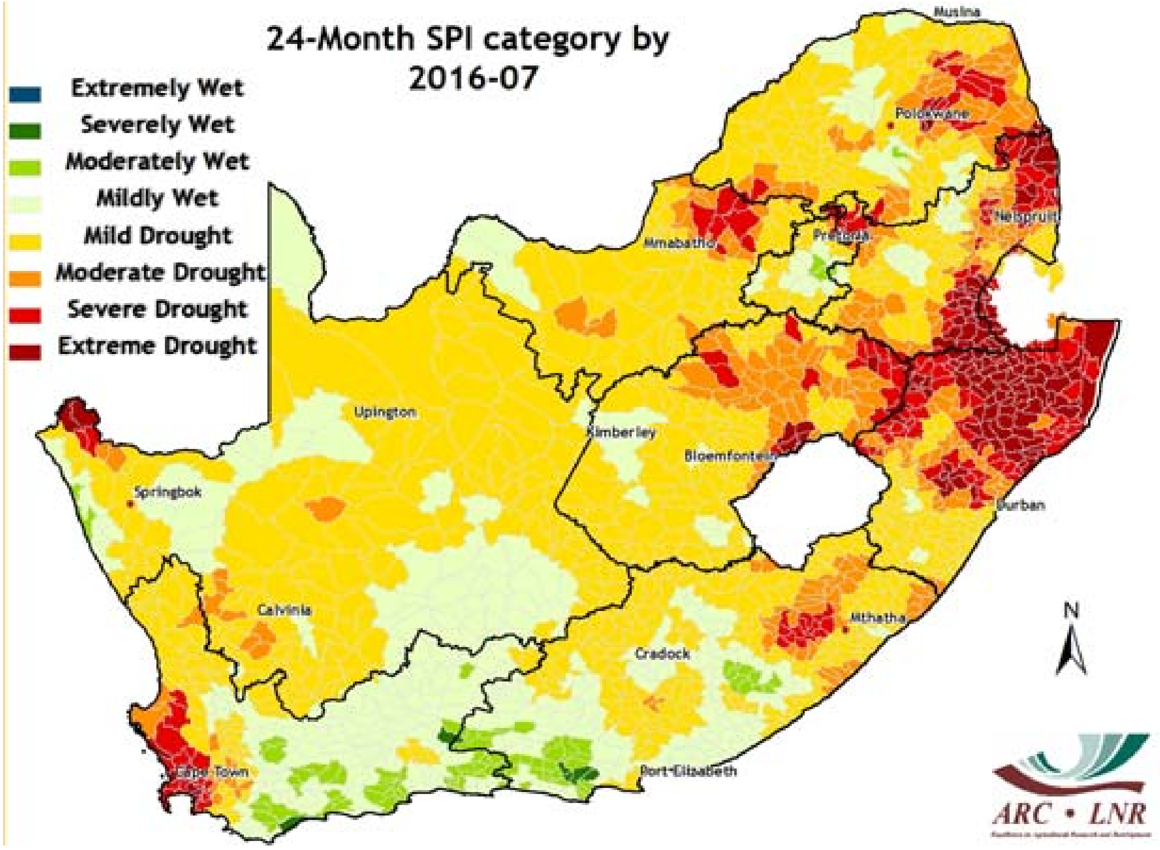

Figure 8

3. Rainfall Deciles

Deciles are used to express the ranking of rainfall for a specific period in terms of the historical time series. In the map, a value of 5 represents the median value for the time series. A value of 1 refers to the rainfall being as low or lower than experienced in the driest 10% of a particular month historically (even possibly the lowest on record for some areas), while a value of 10 represents rainfall as high as the value recorded only in the wettest 10% of the same period in the past (or even the highest on record). It therefore adds a measure of significance to the rainfall deviation.

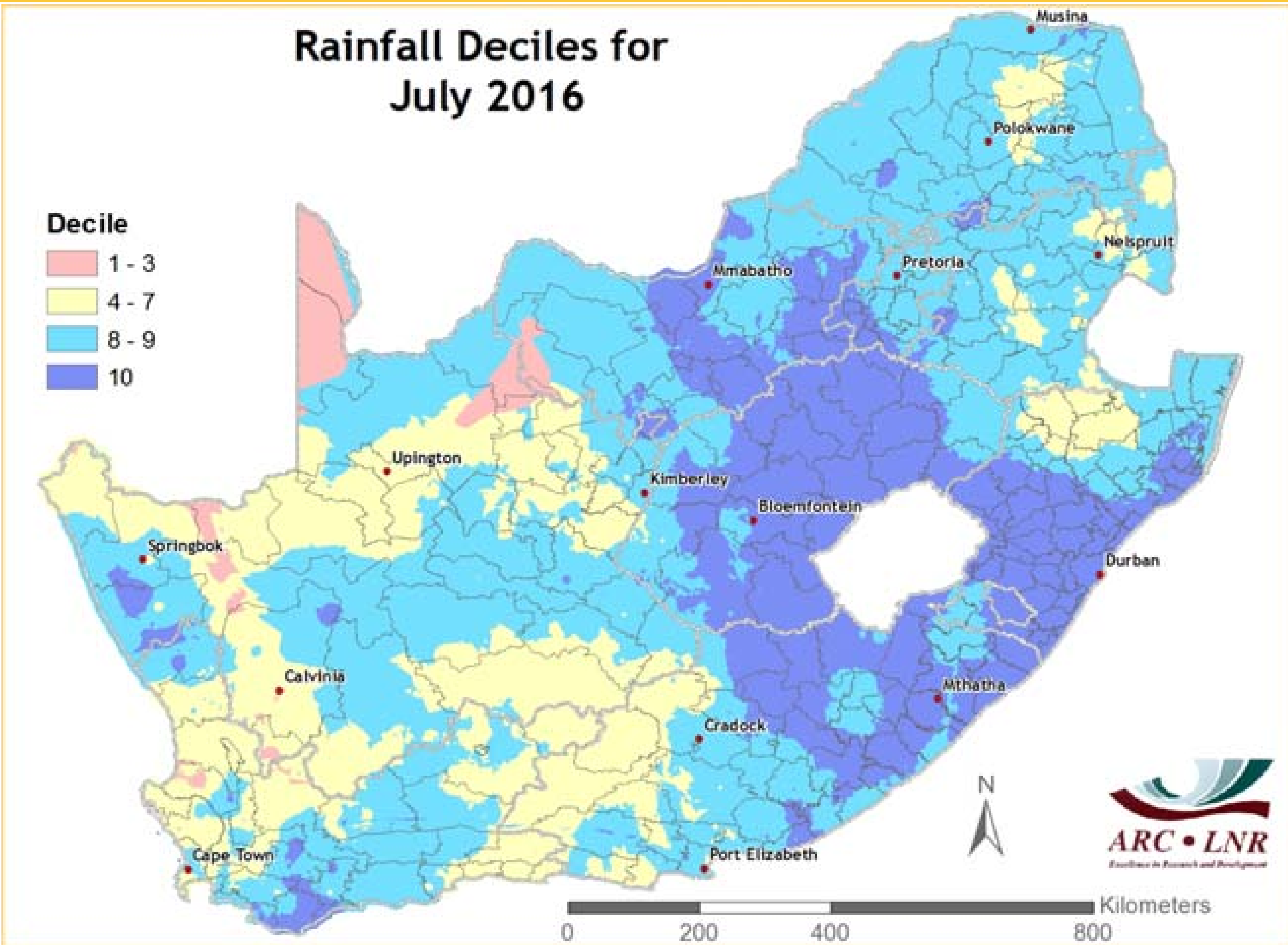

Figure 9

Figure 9:
Large parts of the Free State into southern KwaZulu-Natal were abnormally wet during July.

Questions/Comments: *Johan@arc.agric.za*

4. Water Balance

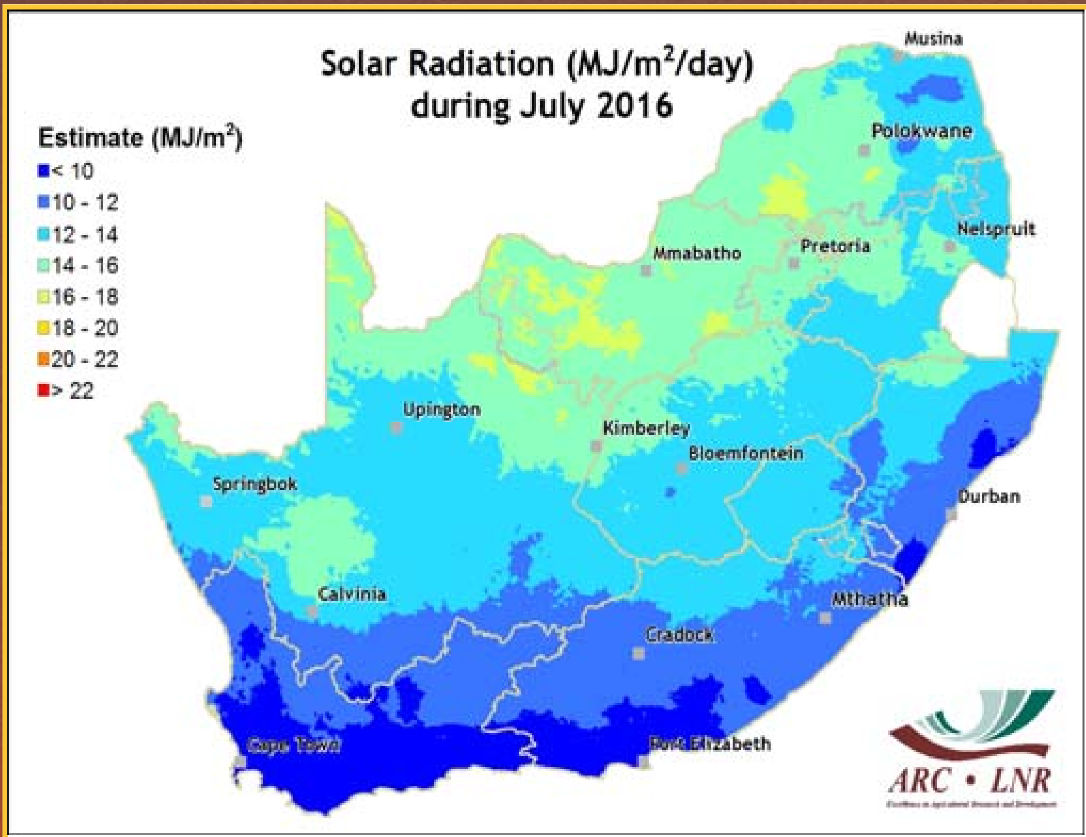

Figure 10

Solar Radiation

Daily solar radiation surfaces are created for South Africa by combining *in situ* measurements from the ARC-ISCW automatic weather station network with 15-minute data from the Meteosat Second Generation satellite.

Figure 10:
Daily solar radiation totals remain low following the winter solstice in late June and due to cloud cover especially towards the south and southeast.

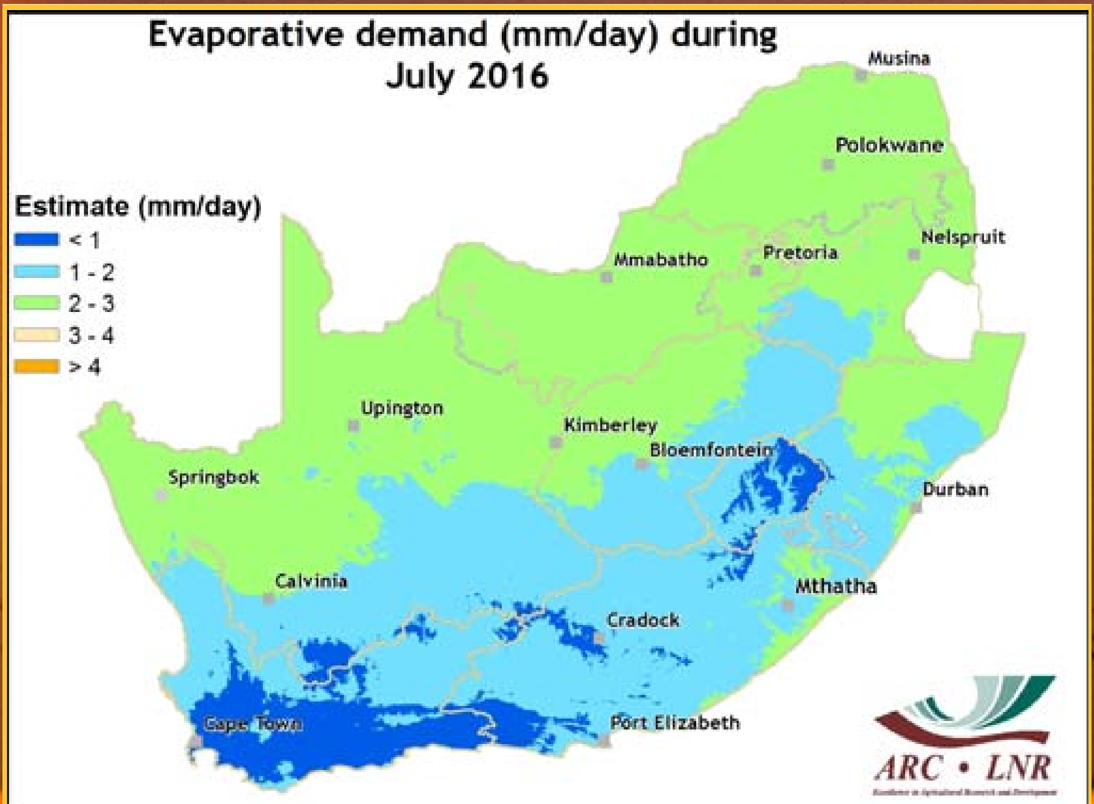

Figure 11

Potential Evapotranspiration

Potential evapotranspiration (PET) for a reference crop is calculated at about 450 automatic weather stations of the ARC-ISCW located across South Africa. At these stations hourly measured temperature, humidity, wind and solar radiation values are combined to estimate the PET.

Figure 11:
Daily potential evapotranspiration values remain low due to conditions associated with midwinter as well as several days with cloud cover over the interior.

Questions/Comments:
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5. Vegetation Conditions

Vegetation Mapping

The Normalized Difference Vegetation Index (NDVI) is computed from the equation:

NDVI=(IR-R)/(IR+R)

where:
IR = Infrared reflectance &
R = Red band

NDVI images describe the vegetation activity. A decadal NDVI image shows the highest possible “greenness” values that have been measured during a 10-day period.

Vegetated areas will generally yield high values because of their relatively high near infrared reflectance and low visible reflectance. For better interpretation and understanding of the NDVI images, a temporal image difference approach for change detection is used.

The Standardized Difference Vegetation Index (SDVI) is the standardized anomaly (according to the specific time of the year) of the NDVI.

Figure 12:
The SDVI by late July reflected recent above-normal rainfall over much of the interior, the coast of KwaZulu-Natal and western parts of the winter rainfall region, as well as dry conditions over the southeastern and eastern low-lying areas.

Figure 13:
Vegetation activity over much of the western grain production region of the winter rainfall region is higher than a year ago. More rain over much of the interior and KwaZulu-Natal coast is also reflected in higher vegetation activity relative to the conditions last year by late July. Vegetation activity over the southeastern parts and northern parts of the West Coast is lower than a year ago.

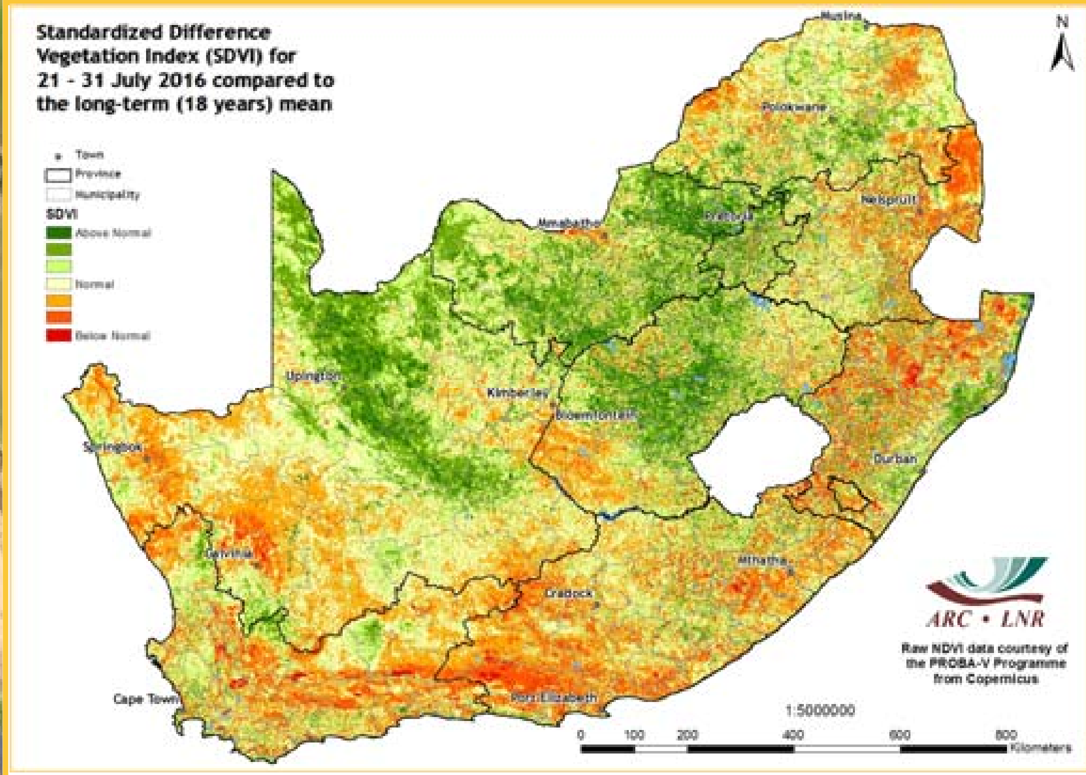

Figure 12

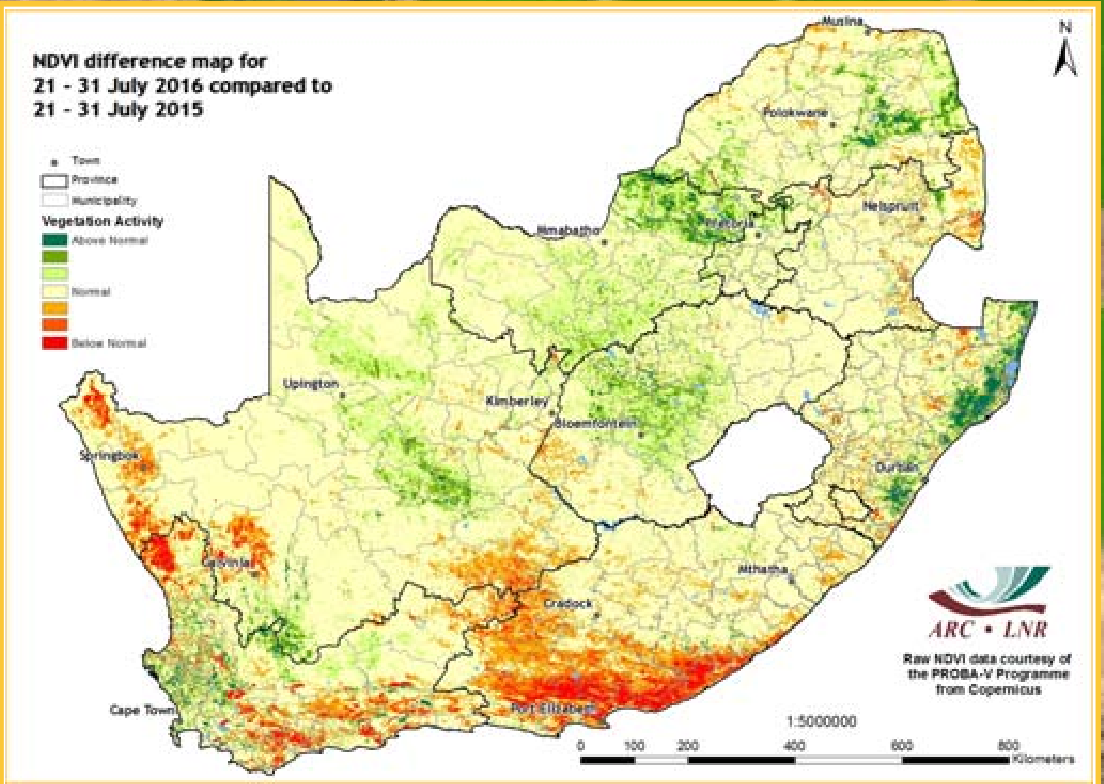

Figure 13

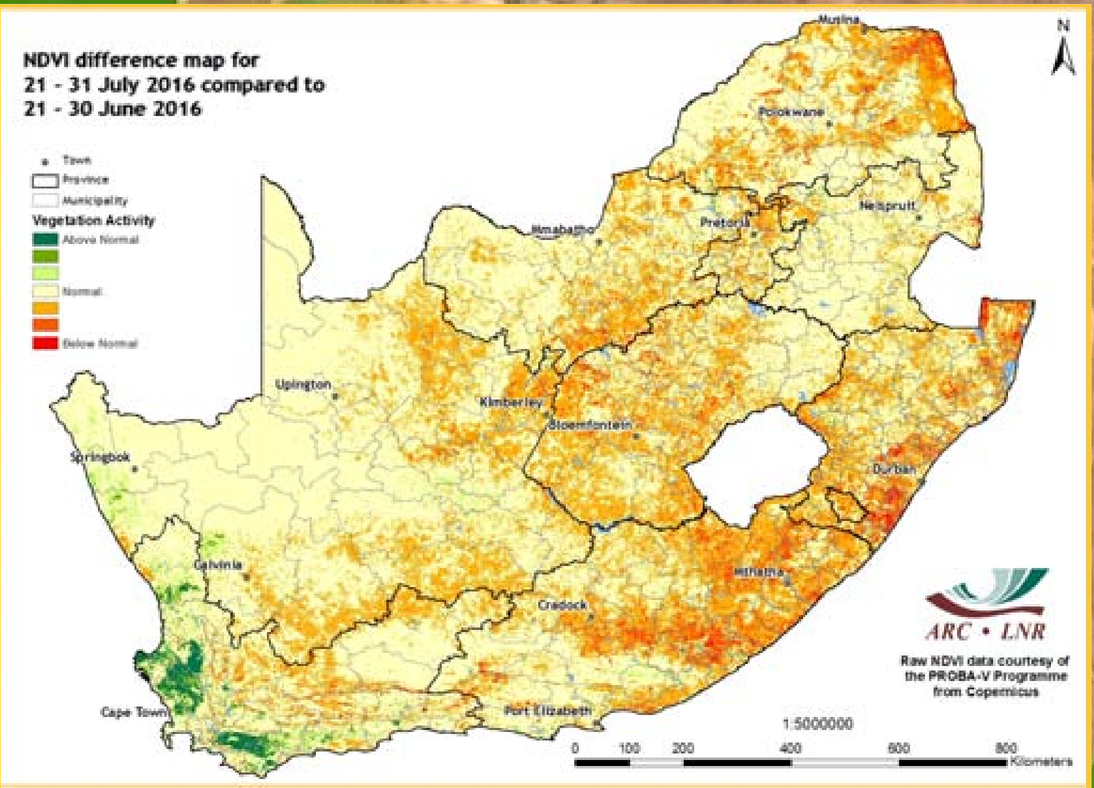

Figure 14

Vegetation Mapping
(continued from p. 8)

Interpretation of map legend

NDVI values range between 0 and 1. These values are incorporated in the legend of the difference maps, ranging from -1 (lower vegetation activity) to 1 (higher vegetation activity) with 0 indicating normal/the same vegetation activity or no significant difference between the images.

Cumulative NDVI maps:

Two cumulative NDVI datasets have been created for drought monitoring purposes:

Winter: January to December
Summer: July to June

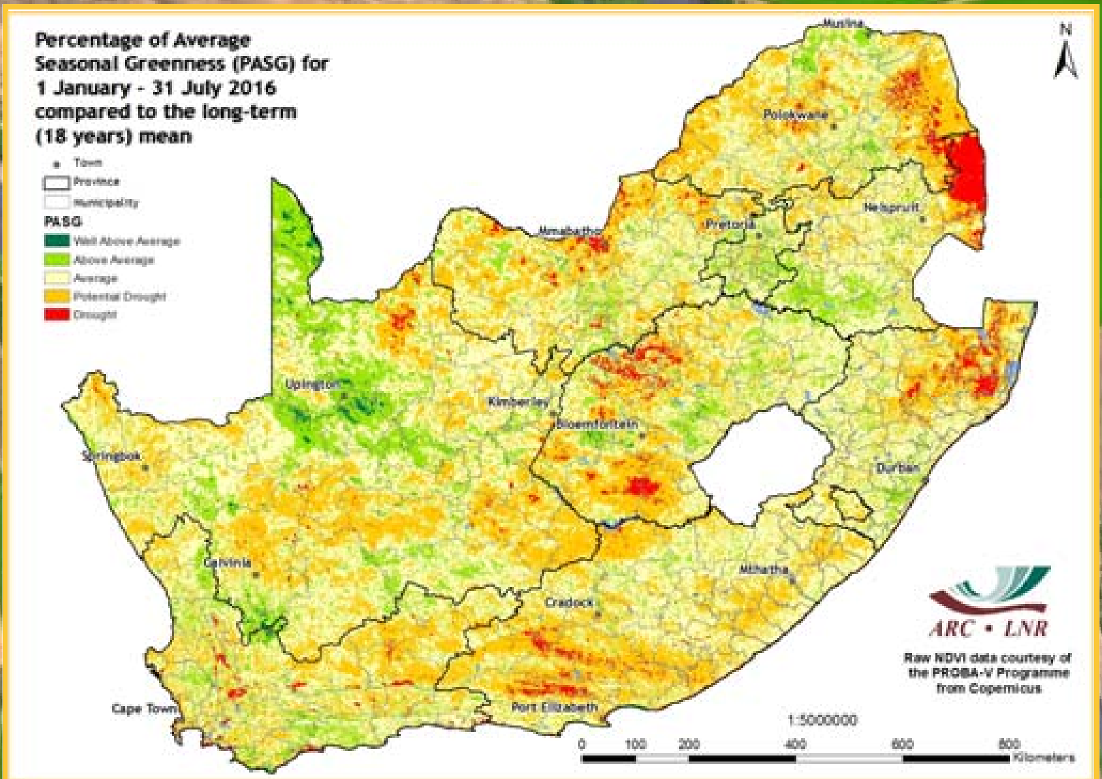

Figure 15

Figure 14:
Temperature and rainfall trends are the main drivers of vegetation activity showing a decreasing tendency over the northeastern parts whilst increasing over the winter rainfall region, particularly the grain production areas.

Figure 15:
Cumulative vegetation activity anomalies still indicate earlier drought stress over much of the central parts of the country as well as the northern parts of KwaZulu-Natal and Lowveld of Mpumalanga. Conditions seem close to the norm over much of the winter rainfall region.

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6. Vegetation Condition Index

Vegetation Condition Index (VCI)

The VCI is an indicator of the vigour of the vegetation cover as a function of the NDVI minimum and maximum encountered for a specific pixel and for a specific period, calculated over many years.
The VCI normalizes the NDVI according to its changeability over many years and results in a consistent index for various land cover types. It is an effort to split the short-term weather-related signal from the long-term climatological signal as reflected by the vegetation. The VCI is a better indicator of water stress than the NDVI.

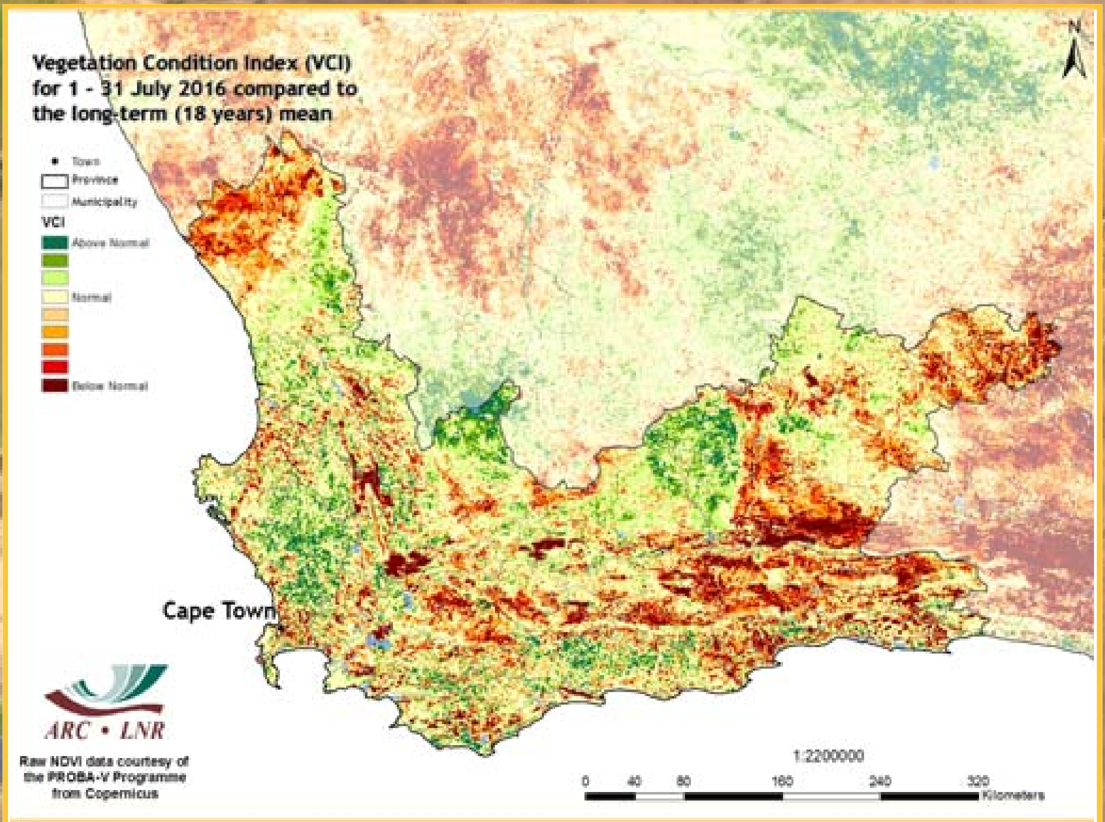

Figure 16

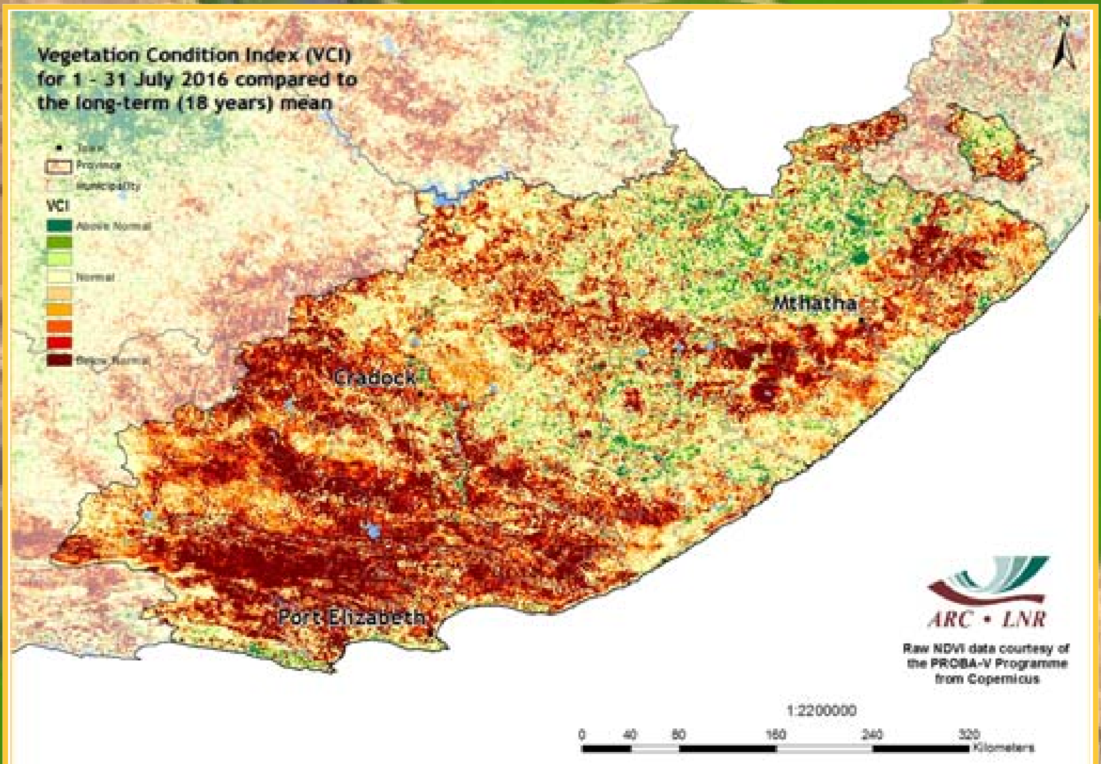

Figure 17

Figure 16:
The VCI map for July indicates below-normal vegetation activity over most parts of Western Cape.

Figure 17:
The VCI map for July indicates below-normal vegetation activity over most parts of the Eastern Cape.

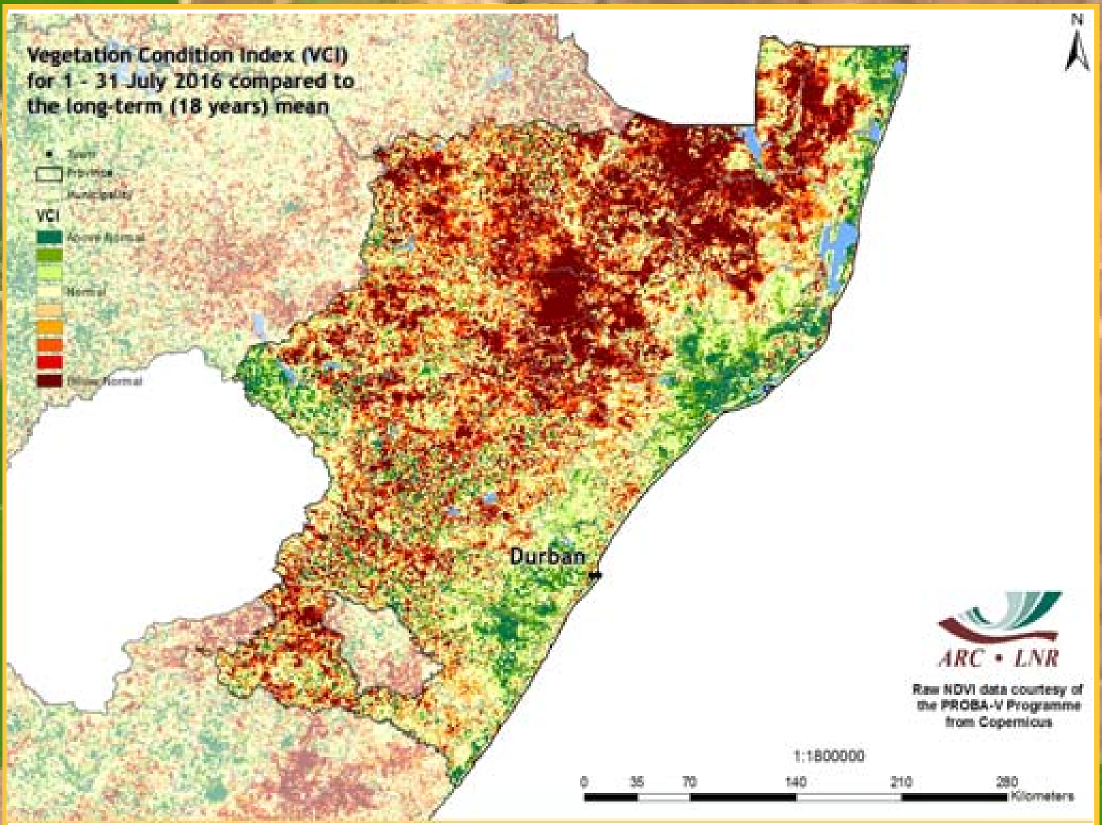

Figure 18

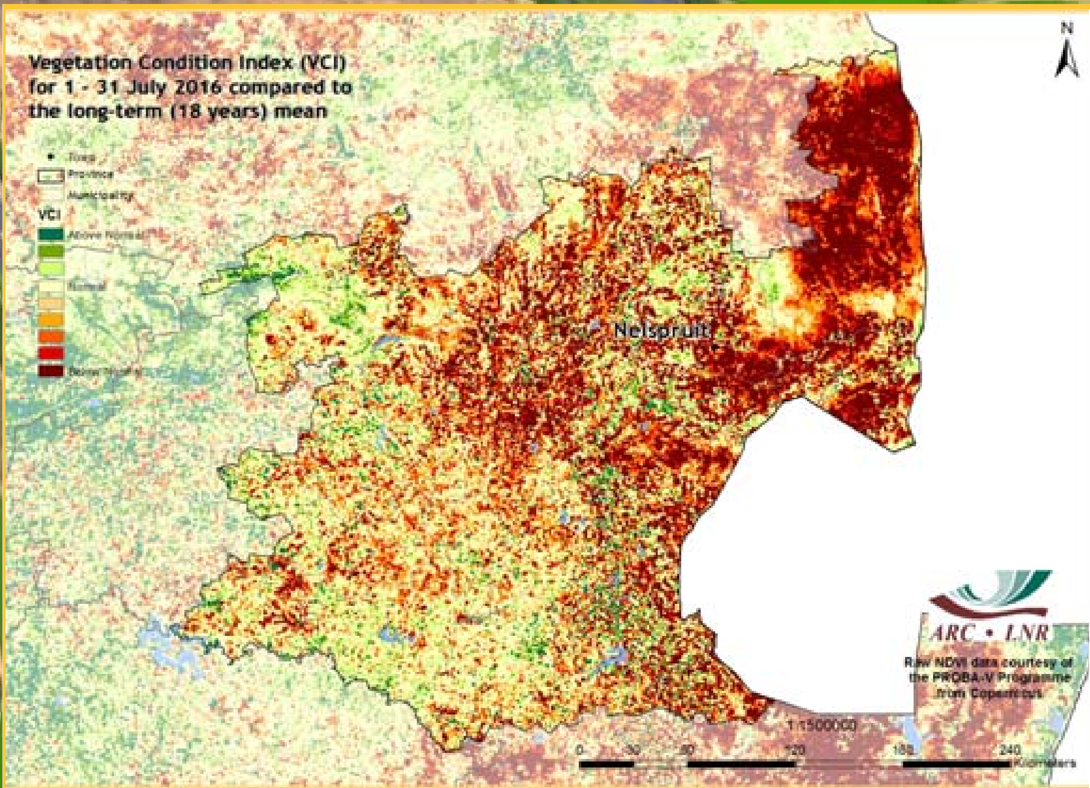

Figure 19

Figure 18:
The VCI map for July indicates below-normal vegetation activity over most parts of KwaZulu-Natal with the exception of the coastal areas.

Figure 19:
The VCI map for July indicates below-normal vegetation activity over most parts of Mpumalanga.

Questions/Comments:
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7. Vegetation Conditions & Rainfall

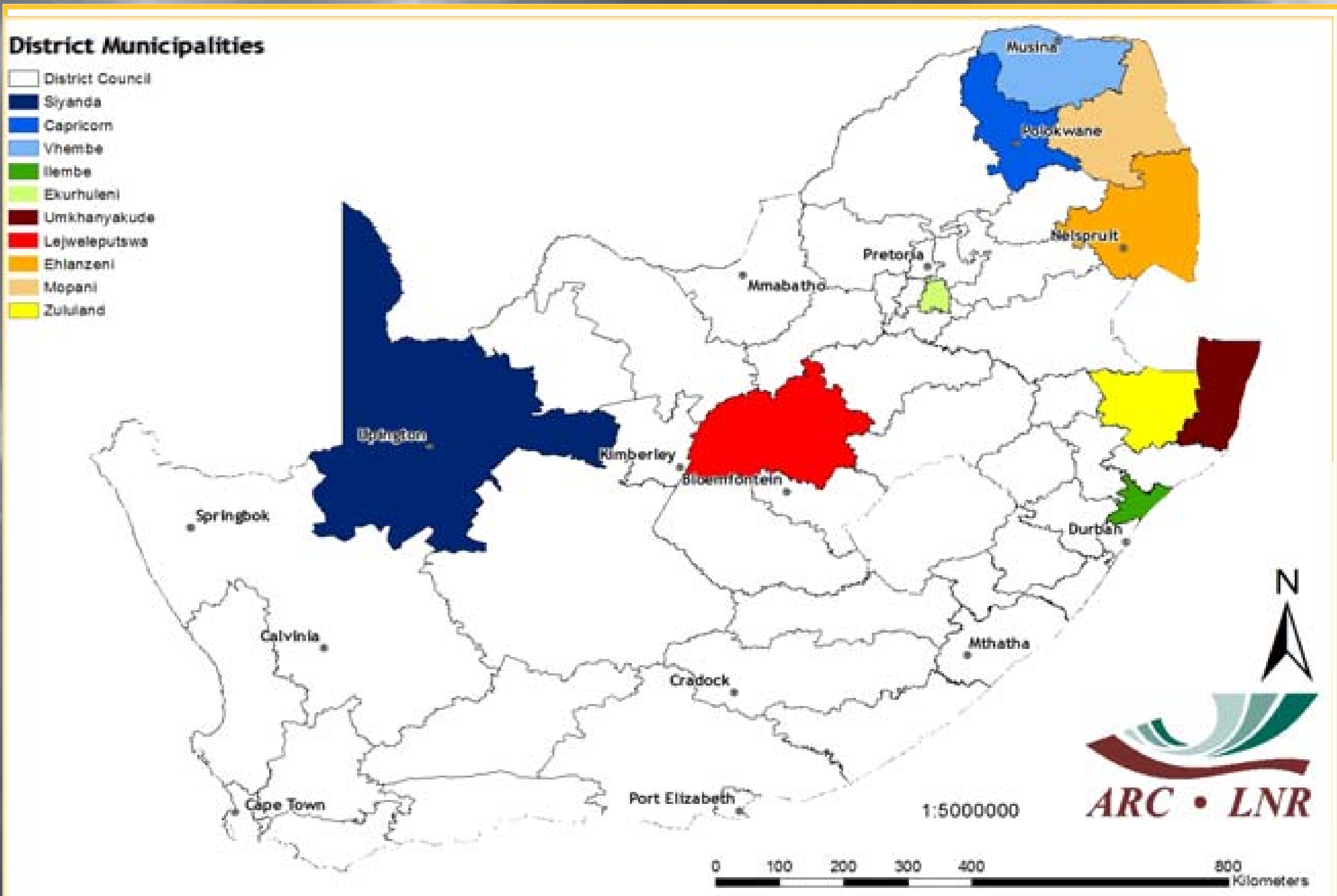


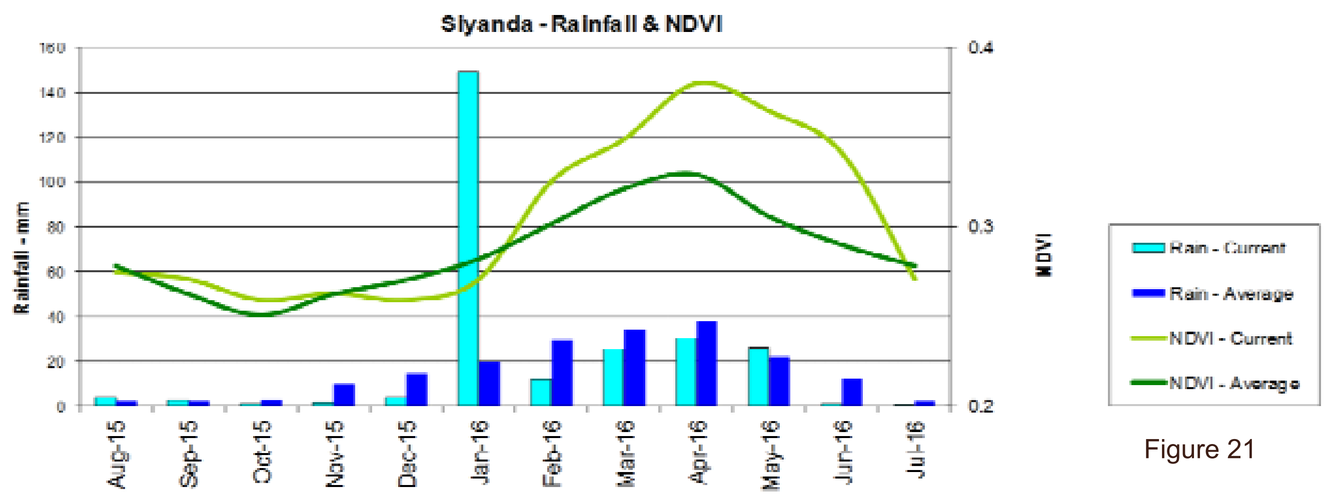
Figure 20

NDVI and Rainfall Graphs
Figure 20:
Orientation map showing the areas of interest for July 2016. The district colour matches the border of the corresponding graph.

Questions/Comments:
Johan@arc.agric.za; NkambuleV@arc.agric.za

Figures 21-25:
Indicate areas with higher cumulative vegetation activity for the last year.

Figures 26-30:
Indicate areas with lower cumulative vegetation activity for the last year.



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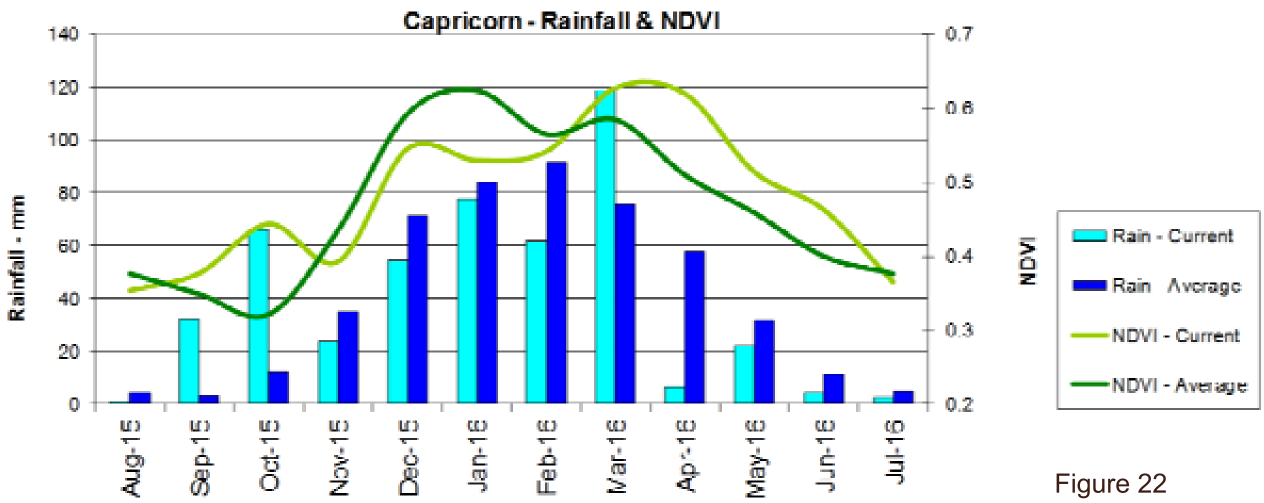

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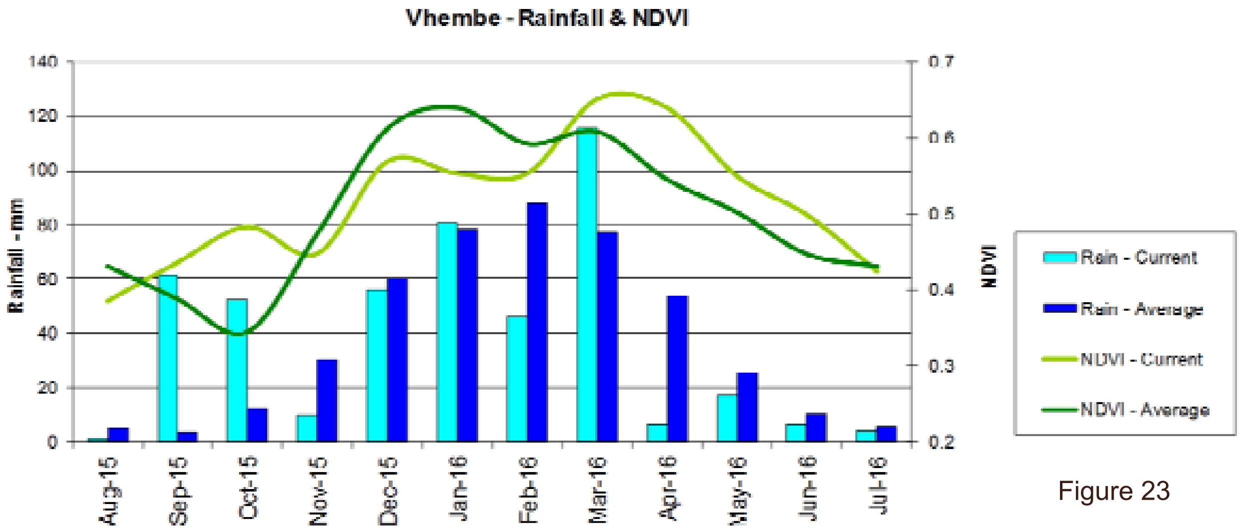

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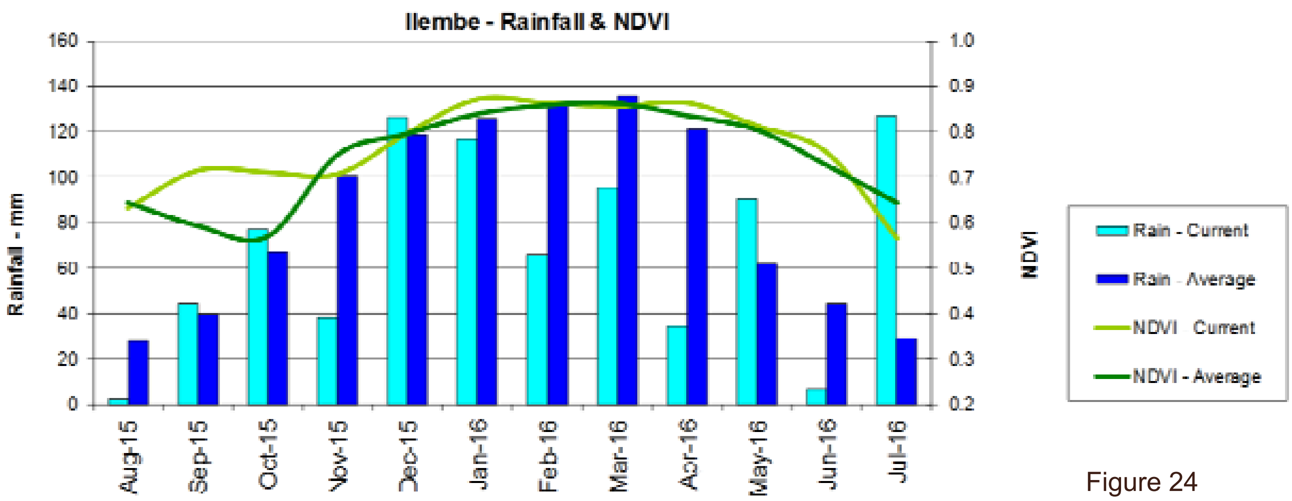

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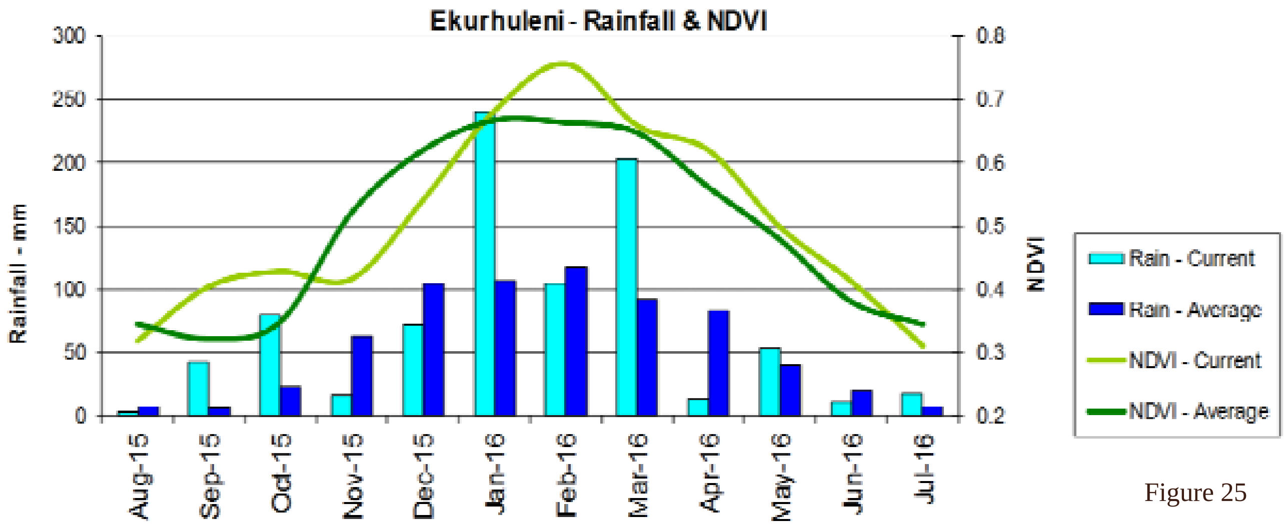

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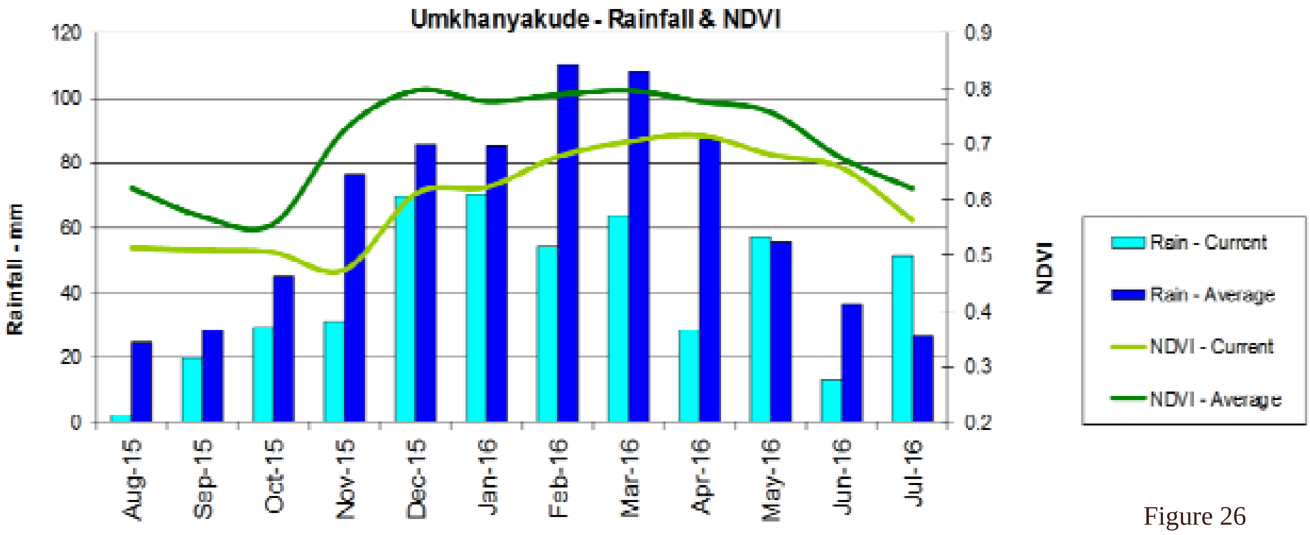

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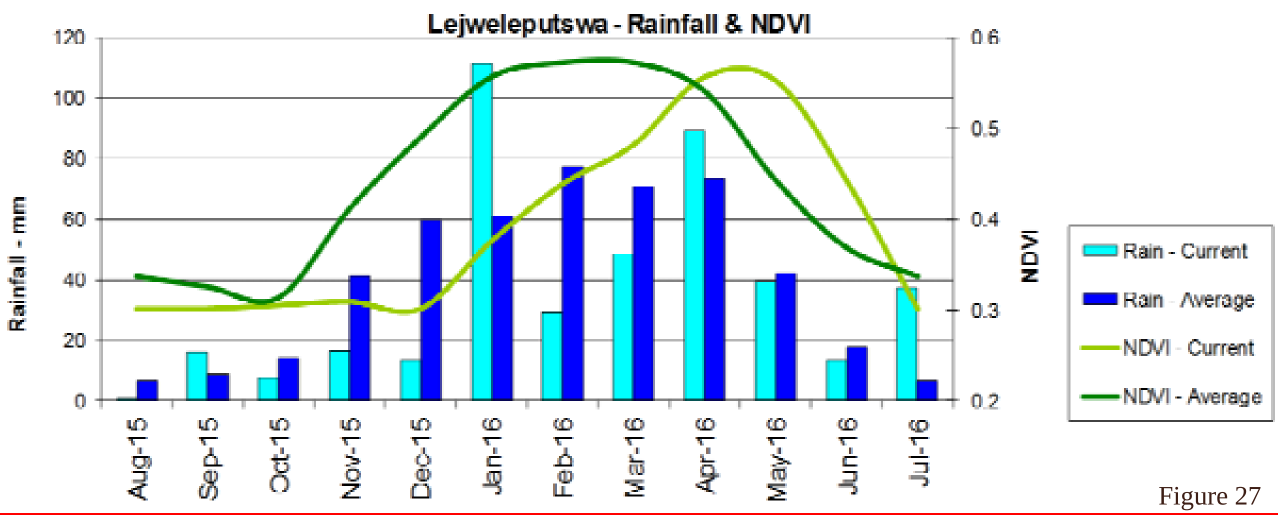

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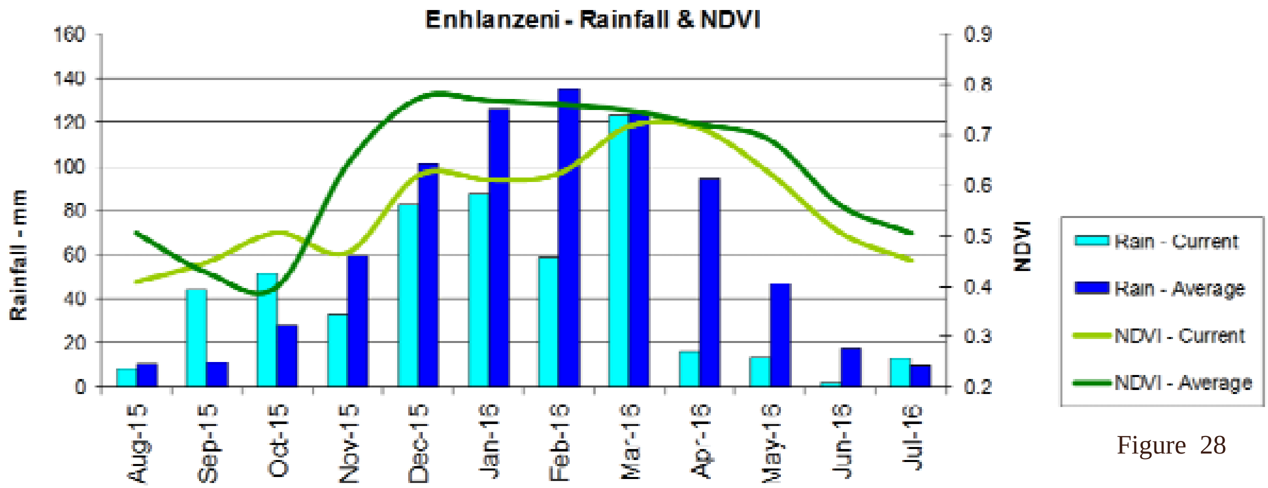

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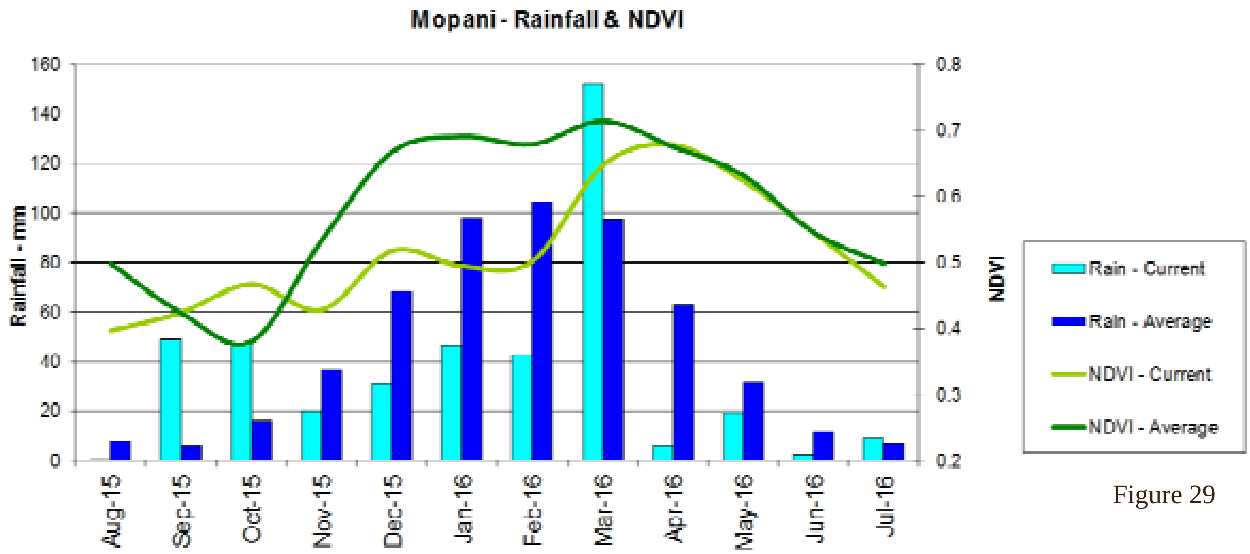

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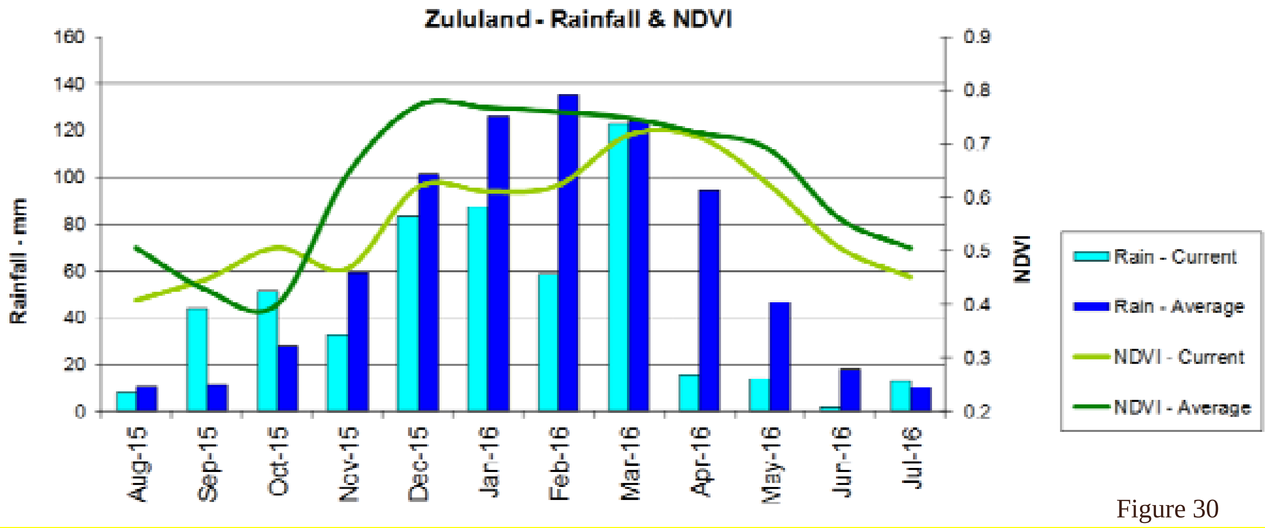

Figure 30

8. Soil Moisture

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Countywide soil moisture modelling by the University of KwaZulu-Natal Satellite Applications and Hydrology Group (SAHG)

Figure 31 shows the monthly averaged soil moisture conditions for July 2016. The colour scale ranging from brown to blue represents the Soil Saturation Index (SSI), defined as the percentage saturation of the soil store in the TOPKAPI hydrological model. The modelling is intended to represent the mean soil moisture state in the root zone. Figure 32 shows the SSI difference between July and June 2016, with the brown colours showing the drier and the green colours the wetter areas. Similarly, the year-on-year SSI difference for July is shown in Figure 33.

The year-on-year and month-on-month SSI differences are in agreement with rainfall and vegetation trends observed elsewhere in the newsletter.

The SSI maps are produced at the ARC-ISCW in a collaborative effort with the University of KwaZulu-Natal Applications and Hydrology Group, made possible by the WMO.

Questions/Comments:
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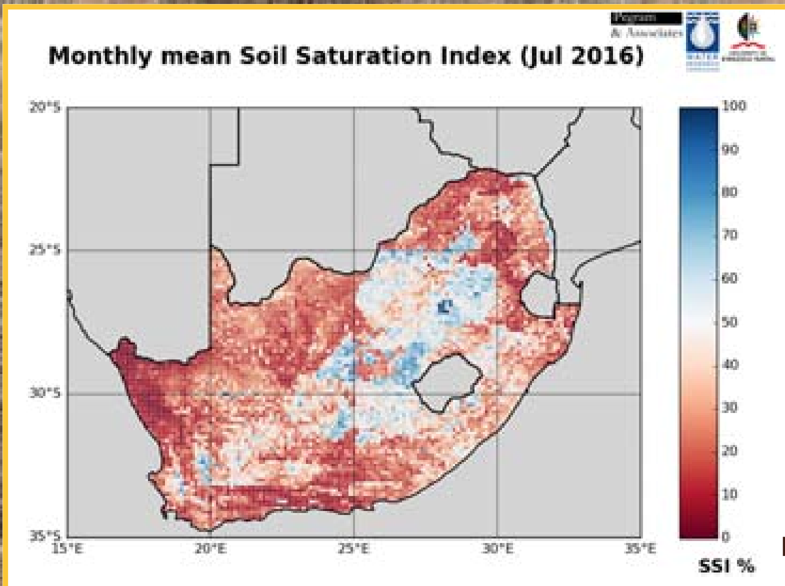

Figure 31

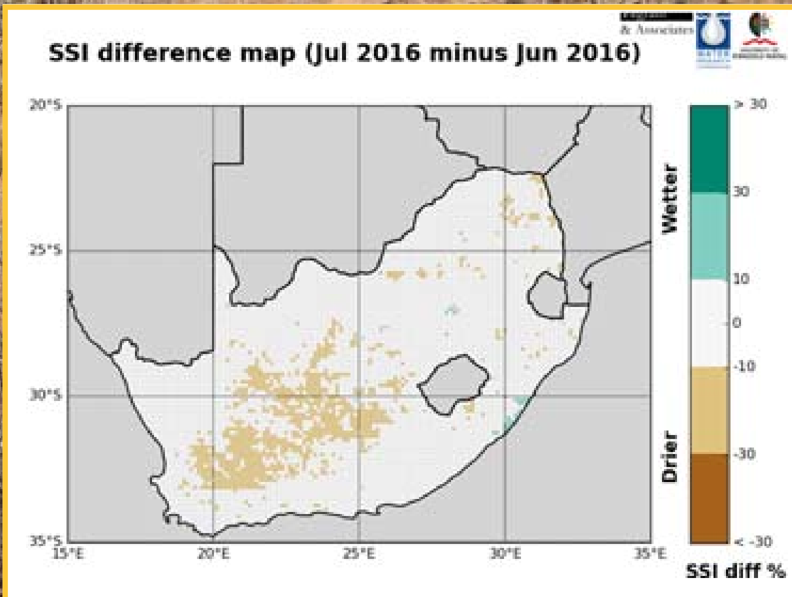

Figure 32

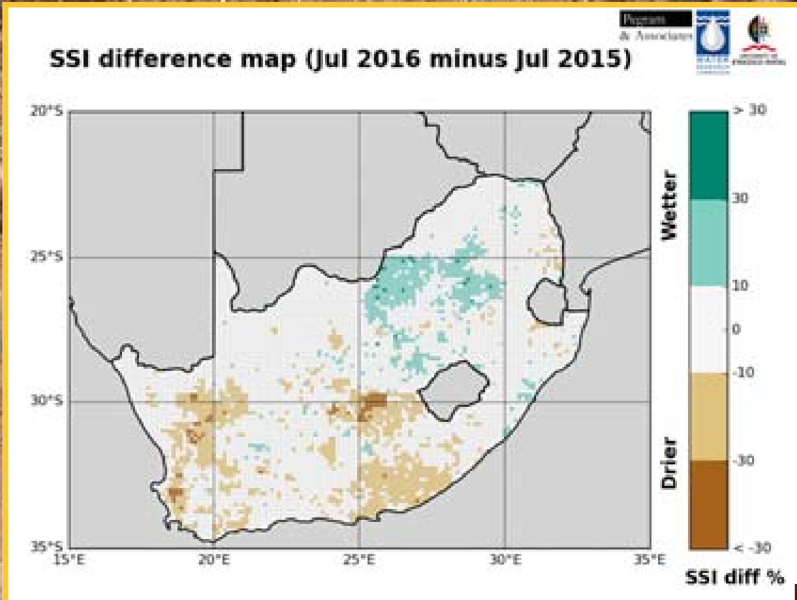

Figure 33

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9. Fire Watch

Active Fires *(Provided when data is available)*

Forest and vegetation fires have temperatures in the range of 500 K (Kelvin) to 1000 K. According to Wien's Displacement Law, the peak emission of radiance for blackbody surfaces of such temperatures is at around 4 μm. For an ambient temperature of 290 K, the peak of radiance emission is located at approximately 11 μm. Active fire detection algorithms from remote sensing use this behaviour to detect "hot spot" fires.

Figure 34:
The graph shows the total number of active fires detected during the month of July per province. Fire activity was higher in Mpumalanga, Northern Cape, Western Cape and KwaZulu-Natal compared to the average during the same period for the last 16 years.

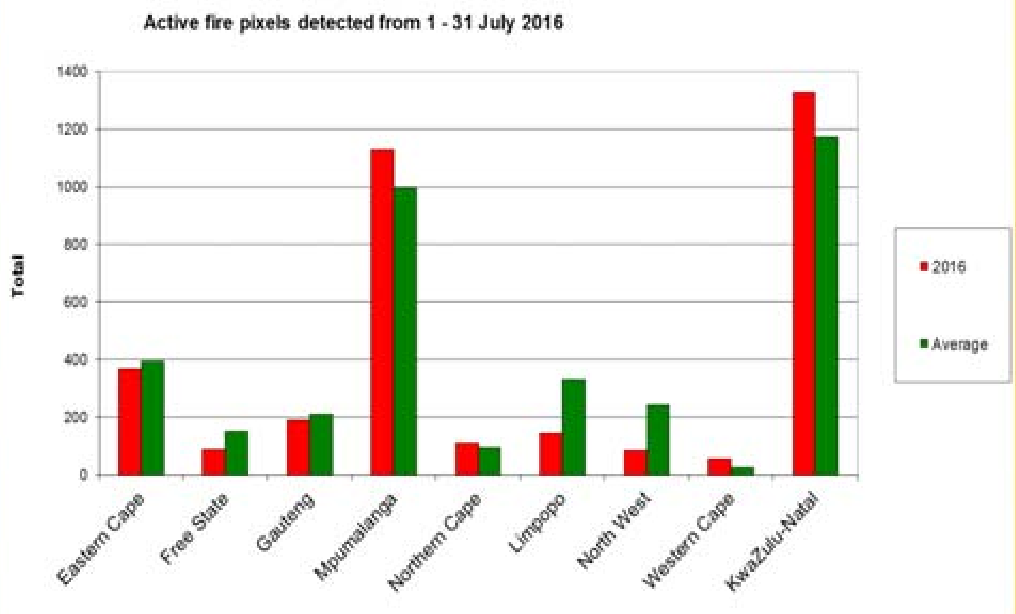

Figure 34

Figure 35:
The map shows the location of active fires detected between 1-31 July 2016.

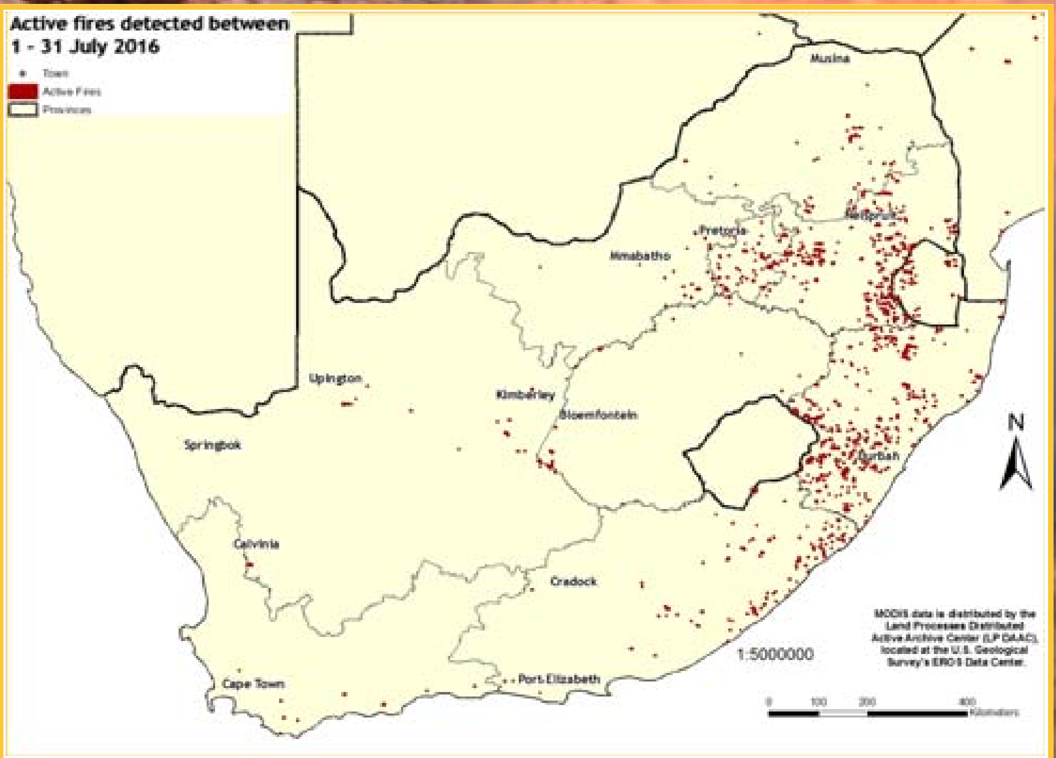

Figure 35

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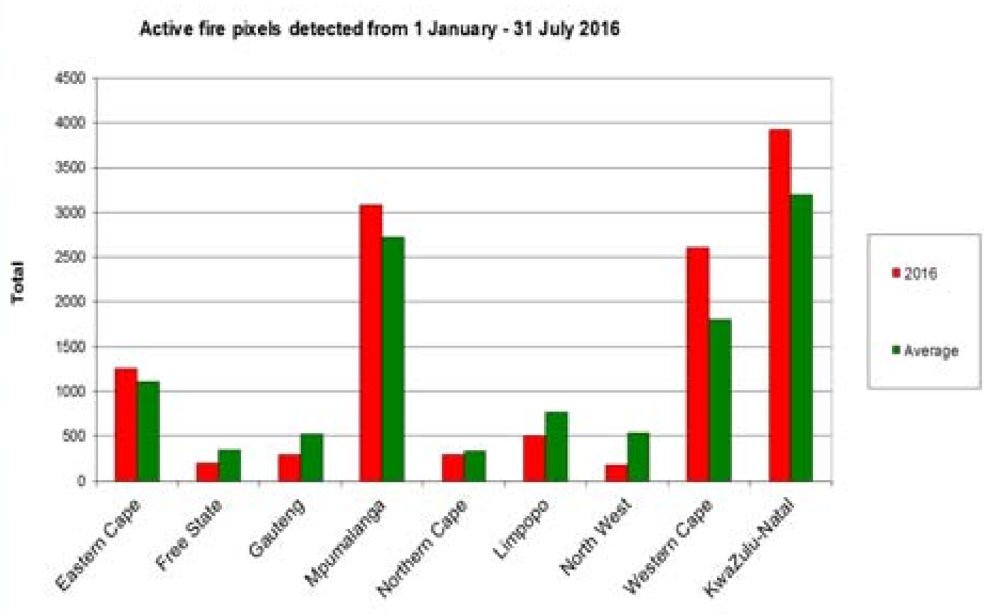

Figure 36

Figure 36:
The graph shows the total number of active fires detected from 1 January - 31 July 2016 per province. Fire activity was higher in the Eastern Cape, Mpumalanga, Western Cape and KwaZulu-Natal compared to the average during the same period for the last 16 years.

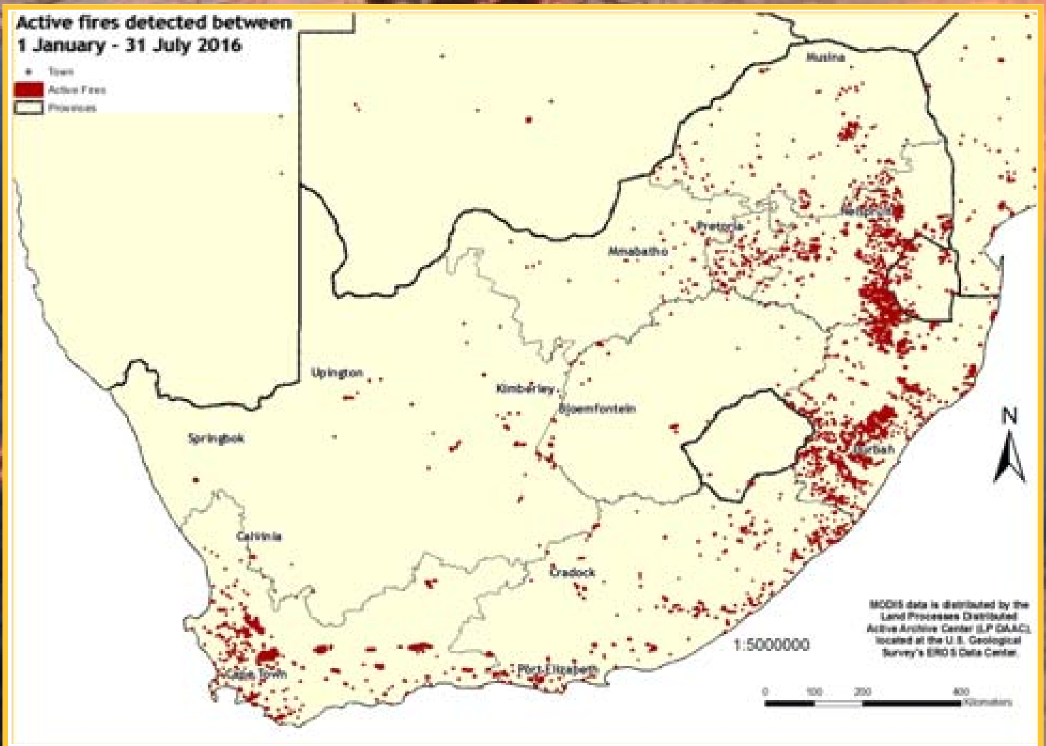

Figure 37

Figure 37:
The map shows the location of active fires detected between 1 January - 31 July 2016.

Questions/Comments:
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Agrometeorology

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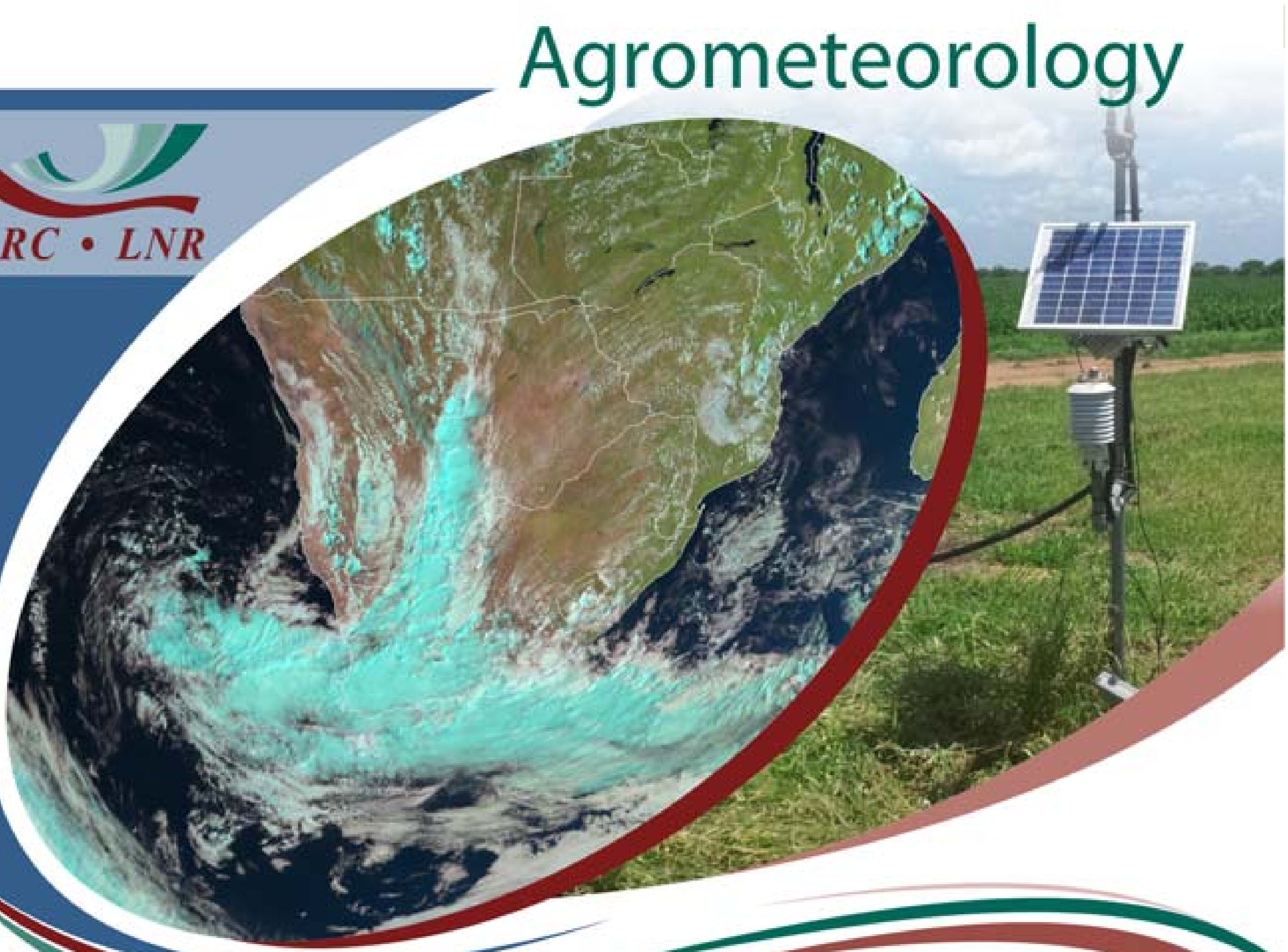

The programme focuses on the use of weather and climate information and monitoring for the forecast and prediction of the weather elements that have direct relevance on agricultural planning and the protection of crop, forest and livestock. The Agro-Climate Network & Databank is maintained as a national asset.

FOCUS AREAS

Climate Monitoring, Analysis & Modelling

- Analysis of climate variability and climate model simulation
- Use of crop modelling to assess the impact of climate on agriculture
- Development of decision support tools for farmers

Climate Change Adaptation & Mitigation

- National greenhouse gas inventory in the agricultural sector
- Improvement of agricultural production technologies under climate change
- Adaptation and mitigation initiatives, e.g. biogas production in small-scale farming communities

Climate Information Dissemination

- Communication to farmers for alleviating weather-related disasters such as droughts
- Dissemination of information collected from weather stations
- Climate change awareness campaigns in farming communities

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Geoinformation Science

The programme focuses on applied Geographical Information Systems (GIS) and Earth Observation (EO)/Remote Sensing research and provides leadership in applied GIS products, solutions, and decision support systems for agriculture and natural resources management. The Coarse Resolution Satellite Image Archive and Information Database is maintained as a national asset.

FOCUS AREAS

Decision Support Systems

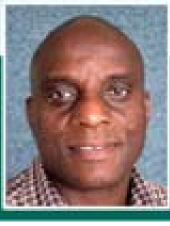
- Spatially explicit information dissemination systems, e.g. Umlindi newsletter
- Crop and land suitability modelling/assessments
- Disease and pest outbreaks and distribution modelling
- Precision agriculture information systems

Early Warning & Food Security

- Drought and vegetation production monitoring
- Crop estimates and yield modelling
- Animal biomass and grazing capacity mapping
- Global and local agricultural outlook forecasts
- Disaster monitoring for agricultural systems

Natural Resources Monitoring

- Land use/cover mapping
- Invasive species distribution
- Applications of GIS and EO on land degradation/erosion, desertification, hydrology and catchment areas
- Rangeland health assessments
- Carbon inventory monitoring



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The Coarse Resolution Imagery Database (CRID)

NOAA AVHRR

The ARC-ISCW has an archive of daily NOAA AVHRR data dating from 1985 to 2004. This database includes all 5 bands as well as the Normalized Difference Vegetation Index (NDVI), Active Fire and Land Surface Temperature (LST) images. The NOAA data are used, for example, for crop production and grazing capacity estimation.

MODIS

MODIS data is distributed by the Land Processes Distributed Active Archive Center (LP DAAC), located at the U.S. Geological Survey's EROS Data Center. The MODIS sensor is more advanced than NOAA with regard to its high spatial (250 m^2 to 1 km^2) and spectral resolution. The ARC-ISCW has an archive of MODIS (version 4 and 5) data.

- MODIS v4 from 2000 to 2006
- MODIS v5 from 2000 to present

Datasets include:

- MOD09 (Surface Reflectance)
- MOD11 (Land Surface Temperature)
- MOD13 (Vegetation Products)
- MOD14 (Active Fire)
- MOD15 (Leaf Area Index & Fraction of Photosynthetically Active Radiation
- MOD17 (Gross Primary Productivity)
- MCD43 (Albedo & Nadir Reflectance)
- MCD45 (Burn Scar)

Coverage for version 5 includes South Africa, Namibia, Botswana, Zimbabwe and Mozambique.
More information:
http://modis.gsfc.nasa.gov

VGT4AFRICA and GEOSUCCESS

SPOT NDVI data is provided courtesy of the VEGETATION Programme and the VGT4AFRICA project. The European Commission jointly developed the VEGETATION Programme. The VGT4AFRICA project disseminates VEGETATION products in Africa through GEONETCast.

ARC-ISCW has an archive of VEGETATION data dating from 1998 to the present. Other products distributed through VGT4AFRICA and GEOSUCCESS include Net Primary Productivity, Normalized Difference Wetness Index and Dry Matter Productivity data.

Meteosat Second Generation (MSG)

The ARC-ISCW has an operational MSG receiving station. Data from April 2005 to the present have been archived. MSG produces data with a 15-minute temporal resolution for the entire African continent. Over South Africa the spatial resolution of the data is in the order of 3 km. The ARC-ISCW investigated the potential for the development of products for application in agriculture. NDVI, LST and cloud cover products were some of the initial products derived from the MSG SEVIRI data. Other products derived from MSG used weather station data, including air temperature, humidity and solar radiation.

Rainfall maps

- Combined inputs from 450 automatic weather stations from the ARC-ISCW weather station network, 270 automatic rainfall recording stations from the SAWS, satellite rainfall estimates from the Famine Early Warning System Network: **http://earlywarning.usgs.gov** and long-term average climate surfaces developed at the ARC-ISCW.

Solar Radiation and Evapotranspiration maps

- Combined inputs from 450 automatic weather stations from the ARC-ISCW weather station network.
- Data from the METEOSAT Second Generation (MSG) 3 satellite via GEONETCAST: **http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/GEONETCast/index.html**.

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Excellence in Agricultural Research and Development

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The operational Coarse Resolution Imagery Database (CRID) project of ARC-ISCW is funded by the National Department of Agriculture, Forestry and Fisheries. Development of the monitoring system was made possible at its inception through LEAD funding from the Department of Science and Technology.

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What does Umlindi mean?
UMLINDI is the Zulu word for "the watchman".

http://www.agis.agric.za